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GEOLOGICAL SURVEY OF ALABAMA
EUGENE ALLEN SMITH, *State Geologist*

BULLETIN NO. 20

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1916

COMPILED FROM THE MINERAL RESOURCES OF THE UNITED STATES

By
EUGENE A. SMITH

UNIVERSITY, ALABAMA
1918

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LETTER OF TRANSMITTAL

UNIVERSITY, ALA., December 15, 1918.

HON. CHARLES HENDERSON,

Governor of Alabama,

Montgomery, Ala.

SIR:—I have the honor to transmit herewith the manuscript of a Report on the Mineral Production of Alabama for the year 1916 with the request that it be printed as Bulletin No. 20 of the Geological Survey of Alabama.

Very respectfully,

EUGENE A. SMITH,

State Geologist.

GEOLOGICAL CORPS.

Eugene Allen Smith, Ph. D.....State Geologist
William F. Prouty, Ph. D.....Chief Assistant
Robert S. Hodges.....Chemist
Herbert H. Smith.....Curator of Museum
Roland M. Harper, Ph. D.....Botanist
A. T. Donoho.....Stenographer
Geo. N. Brewer.....Field Assistant

RIVER GAGE HEIGHT OBSERVERS.

Conecuh River at Beck, Alabama.

S. T. Dillard.....Andalusia, Ala.
In service from October 1, 1914, to September 30, 1915

A. W. Lambert.....Route F, Andalusia, Ala.
From October 1, 1915, to January 31, 1918

C. E. Raley.....Route C, Andalusia, Ala.
From February 1, 1918, to September 30, 1918

Coosa River at Riverside, Ala.

J. E. Whitehead.....October 1, 1914, to April 30, 1918
When the station was discontinued

Tallapoosa River at Sturdevant, Ala.

C. J. Stowe.....October 1, 1914, to December 31, 1915
A. L. Stowe.....January 1, 1916, to September 30, 1918

Big Bear River near Red Bay, Ala.

Ed Bullen.....October 1, 1914, to September 30, 1918

Observations are made every day by these observers of the gage readings at the several stations. From these records when extended through sufficient time, the calculation of available horse power to be obtained from the different streams is made.

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PREFACE

The statistics of all the minerals included in the following pages have been collected in coöperation with the United States Geological Survey, and have been compiled from advance chapters of the *Mineral Resources of the United States*, a publication of the Federal Survey.

The introductory and general matter in each of these articles has either been taken without change from the U. S. advance chapters or has been rearranged or condensed from these chapters, or entirely rewritten to suit it to our present purposes. In each case credit it given to the author.

INTRODUCTION

EUGENE ALLEN SMITH.

AN INSPECTION of the subjoined tables will show that there has been in 1916 an increase both in quantity and value of the mineral products of the State with the exception of gravel, bauxite and sandstone, and an increase in the quantity of mica but a decrease in the value.

Following the plan set out by Mr. E. W. Parker in 1913, and continued by the Alabama Survey, we pass in review the production in 1915 and 1916 of Alabama minerals, and their immediate derived products, taking them up somewhat in the order of their commercial importance.

Coal.—Alabama's production of coal in 1916 was 18,086,197 short tons, valued at $24,859,831, an increase of 21.1 per cent in the quantity and 30.4 per cent in value as compared with 1915. As in 1915, the value of coal products in Alabama in 1916 was approximately three-fifths of the total mineral output of the State.

Coke.—The coke production of Alabama increased from 3,071,811 short tons, valued at $8,545,555, in 1915, to 4,298,417 tons valued at $15,019,139 in 1916, an increase in the value of 75.51 per cent.

Iron Ore.—In 1916 there was an increase of 27.09 per cent in the total quantity of iron ore production in the State as compared with 1915. 29.44 per cent in the quantity of the hematite and 15.06 per cent in the quantity of the brown ore.

Pig Iron.—In the quantity of pig iron marketed in Alabama in 1916, there was an increase from 1915 of 352,243 gross tons, or 15 per cent and of $15,237,536, or 64 per cent in the value. The value of this iron ore production, and not the value of the pig iron, is used in making up the total value of the mineral products of the State.

The total value of the mineral production of Alabama, excluding the value of pig iron and coke, and including the value of the iron ores and the coal was in 1916 $40,973,430, compared with $29,489,279 in 1915, of which, as already stated

approximately three-fifths is represented by the products of the coal mines. More than one-fourth of the total value was contributed by the iron mines. The increase in 1916 from 1914 was $5,793,788, or 30.4 per cent.

The principal coal producing counties are Jefferson, Walker, Bibb, Tuscaloosa, and St. Clair, in the order named. The principal iron ore counties are Jefferson, Tuscaloosa, Franklin and Etowah. The combined value of the pig iron and coke made in Alabama in 1916 was $54,013,799. These values are not included in the total as they are represented in the value of the iron ore and coal produced.

Clay-Working Industries.—These industries yielded products in 1916 valued at $1,520,301 as against $1,193,022 in 1915, an increase of $327,279 or 27.43 per cent. This does not include the value of the raw clay sold, which in 1916 amounted to $51,053, an increase in 1916 of 44.9 per cent.

The center of the clay-working industry is Jefferson county, and Birmingham furnishes the principal market. Vitrified front and fire brick, represent a value of $667,536, or 134.2 of the value of the common brick, while the total output of the brick yard makes up 76.6 per cent of the total value of the clay products of the State. All the fire brick is reported from Jefferson, Baldwin and Calhoun counties, and all the vitrified brick is from Jefferson and St. Clair counties. Clay pits for the manufacture of common brick have been opened in one or more places in thirty-two counties.

The pottery products in 1916 consisted of stone-ware, yellow and Rockingham ware, and red earthen ware, including turpentine cups, and represented a value of $22,805, an increase over 1915 of $7,508, or 49.1 per cent.

Stone.—The quarry products, the greater part of which is limestone, valued in 1916 at $1,202,256, an increase from 1915 of $482,804, or 67.17 per cent. This increase was mainly in the limestone used for flux and in lesser degree in the limestone used for building purposes.

Over 76 per cent of the total value of the stone production in 1916 is that of the limestone. Its most important uses are for furnace flux, concrete, riprap, and for building purposes. The production of marble in 1916 was practically the same as

that in 1915. The figures of production cannot be given because of limited number of producers.

Marble holds the second place in the value of quarry products. Beautiful white marble occurring in Coosa and Talladega counties, being extensively used for building work, (both inside and outside). A black marble, which gives promise of future development, has been prospected near Anniston and near Piedmont.

The reader is referred to the body of this Bulletin, under Stone, for further details concerning especially the building stone and marble industries.

Cement.—The cement production of Alabama in 1916 amounted to 1,442,475 barrels, valued at $1,410,104 as against 1,114,386 barrels, valued at $891,473 in 1915. This was an increase of 29.4 in quantity and 58.2 per cent in value.

Lime.—The lime production is not included in that of the limestone. It amounted in 1916 to 67,524 short tons, an increase from the 1915 production of 7,192 tons, or 11.92 per cent. The value of the product is $312,531, an increase from 1915 of $62,304, or 24.89 per cent.

Graphite.—The Alabama graphite is all of the crystalline variety, and the value of the product in 1916 was $492,407 as against $204,572 in 1915, an increase of 140.7 per cent. The Alabama product for 1916 was 54 per cent of the total value of the crystalline graphite for the United States. The great increase in the production and value of the Alabama graphite since 1915, and the installing of a number of new plants in 1916 make it probable that the Alabama production in coming years will represent an even larger proportion of the total U. S. value.

Minor Products.—Alabama produces a small quantity of gold and silver, and other minor products are barytes, bauxite, mill stones, mineral waters, natural gas, sand and gravel, and quartz.

In the following table there is a comparison of the mineral output in Alabama in the years 1915 and 1916. As stated above, the total does not include the value of the pig iron or that of the coke, but it does include the value of the coal made into coke, and of the iron ore sold or used in making pig iron.

Mineral production of Alabama in 1915 and 1916.

PRODUCT	1915				1916			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quant'y.	Value.	Quantity	Value.	Quantity.	Value.
Coal, short tons	14,927,937	$19,066,033			18,086,197	$24,859,831		
Coke, short tons			3,071,811	$ 8,545,555			4,298,417	$15,019,139
Iron Ore, long tons	5,134,955	6,798,266			6,801,839	10,843,231		
Pig Iron, long tons			2,320,255	23,757,124			2,672,498	38,994,660
Limestone, exclusive of marble		426,266				917,559		
Cement, barrels			1,114,386	891,483			1,442,475	1,410,104
Lime, short tons			60,322	250,227			67,524	312,531
Marble				*				*
Clay, short tons	31,870	35,232			41,479	51,053		
Clay products				1,193,022				1,520,301
Graphite, pounds	3,474,800	204,572			5,226,940	492,407		
Sand and gravel, short tons	924,701	242,336			726,650	184,216		
Bauxite, long tons	*	*			*	*		
Barytes, short tons	*	*			7,631	27,198		
Sandstone, including ganister		30,432				20,995		
Mineral waters, gallons sold	86,499	8,912			103,944	12,174		
Natural gas		*				*		
Gold, fine ounces, Troy			254	5,243			418	8,650
Mica, sheet, pounds			8,400	5,545			14,132	4,955
Mica, scrap, short tons			23	395			65	660
Manganese ore, long tons	*	*			*	*		
Miscellaneous			$328,315			$307,565		
Total†			$29,489,279			$40,973,430		

*Included in Miscellaneous. †Includes Raw and Derived, except Coke and Pig Iron.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1916

ABRASIVES.

EUGENE A. SMITH.

ALABAMA's production of abrasives is at present limited to a small number of millstones (chasers†) quarried and made at Dutton, Jackson County; there are, however, several materials in different parts of the State which are sufficiently promising to be worth investigating and thorough testing; the nature and locality of these deposits were treated in Bulletin No. 13, which see.

BARYTES.

(Condensed from Mineral Resources of the United States.)

JAMES M. HILL.

IN 1916 production from deposits in Alabama was reported by 4 operators, as compared with 1 operator in 1915, and the production increased from less than 500 short tons in 1915 to 7,631 short tons in 1916. In 1916 sales were reported by 4 operators whose average price was $3.56, as compared with 1 operator in 1915 who received essentially the same price.

†Chasers are larger than the regular millstones. They are used for heavier work, such as grinding quartz, feldspar, barytes, etc., and they run on edge. Though they are made with a diameter as short as 24 inches, they are usually turned out with diameters ranging from 50 to 84 inches, and are as much as 22 inches in thickness. These chasers are run on pans paved with roughly cubical blocks of the conglomerate, with edges about a foot in length. In grinding quartz in such pans the chasers are used in the preliminary crushing; then rough blocks, usually three in number, are either attached to or carried along by lateral arms, which in turn are joined to a vertical revolving shaft. By the circular movement of these blocks the material placed in the pan is ground to powder.

Deposits near Jacksonville, Calhoun County; Vincent, Harper, and Wilsonville, Shelby County; and Leeds, Jefferson County, were under development, and a considerable production was made from the mine in Jefferson County, at which a steam-driven hoisting plant and log washer is operated. The mine is about 5 miles south of Leeds in the flat valley bottom of Little Cahaba River. The Chickamauga (Pelham) limestones (Ordovician), in which the valley is cut,* strike north-northeast and dip southeast at steep angles. The mining has exposed the very rough surface of the underlying blue-gray limestone, in which barite in irregular masses replaces the lime and magnesium carbonates. The barytes is mined from the red residual clay overlying the limestone and some large masses of barytes have been found, though the great bulk of the barytes ranges from 1 to 4 inches in size and is of high grade.

From 1 to 3 miles north of Angle station and about 12 miles northwest of Jacksonville, Calhoun County, there are a series of barytes deposits on which a little development has been done. These deposits lie at the base of white quartzite ridge in red residual clay that is derived from blue-gray magnesian limestone, whose age has not been definitely determined but which is probably Knox dolomite.

In the vicinity of Vincent, Harpersville, and Wilsonville, eastern Shelby County, there are small irregular masses of barytes in the red residual clays derived from limestone of Beekmantown age.† Shipments have been made from several small pockets, and it is reported that at a number of places indications point to larger bodies.

Details concerning the manufacture of ground barytes, of lithopone, and of barium chemicals and their uses are given in Bulletin No. 19 of the Alabama Geological Survey, and in the Mineral Resources of the United States for 1916. E. A. S.

*Butts, Charles, U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), 1910.

†Butts, Charles, U. S. Geol. Survey Geol. Atlas, Montevallo-Columbiana folio (in preparation).

BAUXITE AND ALUMINUM.

By JAMES M. HILL.*

BAUXITE.

INTRODUCTION.

BAUXITE, the ore of the widely useful metal aluminum, has also an important use in the manufacture of artificial abrasives and of bauxite brick, more properly called high alumina refractories. It is also the basis of an extensive chemical industry, being the crude material from which alum, aluminum sulphate, and several other aluminum salts are made.

DOMESTIC PRODUCTION.

The production of bauxite in the United States in 1916 was 425,100 long tons, having a value at the mines of $2,296,400, an increase over the production in 1915 of 43 per cent in quantity and 52 per cent in value. The poduction from the Georgia, Alabama, and Tennessee field in 1916 was 49,190 long tons, an increase of about 74 per cent, and the Arkansas production of 375,910 long tons showed an increase of approximately 40 per cent.

Apparently the producers of aluminum consumed about 300,000 tons, makers of chemicals about 80,000 tons, and makers of abrasives and refractories about 45,000 tons of bauxite in 1916.

As will be seen by the following table, though the domestic consumption of bauxite in 1916 also increased 43 per cent over the consumption in 1915, domestic deposits were apparently able to supply the whole demand and still leave some bauxite for export. The larger exports were apparently to Canadian aluminum and abrasive makers.

*The statistical data in this report were prepared by Miss H. M. Gaylord, of the United States Geological Survey.

Bauxite produced and consumed in the United States, 1912-1916.

YEAR.	DOMESTIC PRODUCTION					
	Georgia, Alabama, and Tennessee		Arkansas.		Total	
	Quantity (long tons)	Value.	Quantity (long tons)	Value.	Quantity (long tons)	Value.
1912	42,566	$191,348	117,299	$577,584	159,865	$768,932
1913	40,370	150,710	169,871	846,988	210,241	997,698
1914	24,071	92,508	195,247	976,686	219,318	1,069,194
1915	28,245	144,345	268,796	1,370,489	297,041	1,514,834
1916	49,190	284,810	375,910	2,011,590	425,100	2,296,400

MARKETS AND PRICES.

The market for bauxite in the United States is east of Mississippi River, and the largest consumers are located at or near the following cities: East St. Louis and Auora, Ill.; Detroit, Mich.; Cincinnati, Ohio; Knoxville, Tenn.; Philadelphia and Erie, Pa.; Niagara Falls and New York City, N. Y.; and Boston, Mass. Recently a number of municipal and industrial waterworks have installed small plants for the manufacture of aluminum sulphate for use in purification of water. It is not believed that this new market will materially affect the industry, as it seems probable that its demand will not be great and that the bauxite used may be of lower grade than that accepted by commercial manufacturers.

Bauxite is graded according to its chemical composition and sold to the various consuming industries on the basis of analysis. Apparently, low silica and titanium content is essential to the aluminum industry, but the iron content may be fairly high, though bauxites low in iron and titanium are preferred by the makers of alum and aluminum sulphate. Makers of abrasives appear to be able to use bauxites lower in grade and containing larger proportions of silica and iron than are permissible in bauxites for other uses, but the majority of abrasives are made from bauxites low in silica and iron. The bauxite used for refractories must apparently be fairly low in iron.

The prices received for bauxite in 1916, as reported by producers, ranged from a low of $4.25 to a high of $6.25 a long

ton, the average price for the whole production in 1916 being $5.40 a long ton. During the latter part of the year and early in 1917 higher prices were offered for good grade bauxite from the central Georgia field.

Owing to the freight embargoes placed by various railroads in the last half of 1916 and also to the shortage of cars the producers of bauxite had considerable difficulty in meeting their orders. The exceptionally wet winter was also a handicap to regular production and shipping and, at a few pits in the central Georgia field, work had to be stopped on account of difficult mining or hauling conditions.

OCCURRENCE AND CHARACTER OF BAUXITE IN THE UNITED STATES.

The known commercial bauxite deposits of the United States are in Cherokee, Calhoun, and DeKalb counties, Ala.; Saline and Pulaski counties, Ark.; Wilkinson, Meriwether, and Sumter counties, Ga.; and Hamilton and Carter counties, Tenn.

Clays carrying a large amount of alumina are known in many states, notably central Pennsylvania, northeastern Kentucky, central Indiana, east central Missouri, in the Cretaceous areas of Texas and Alabama, and in the West Coast States. These clays so far as known do not have the characteristics of American bauxite and are not sold as such, though the clay from some of the deposits is used for the manufacture of "high alumina refractories."

All the bauxite mined in the United States is closely associated with kaolin. In the Arkansas field the kaolin is derived from the alteration of syenite in place. In the Tennessee and north Georgia-Alabama fields the origin of the kaolin is not so clear, but it has been formed along faults possibly by the action of circulating waters on the limestone, shale, and quartzitic rocks. In the central-Georgia field the sedimentary kaolins are widespread and were laid down by Cretaceous and Tertiary streams which obtained the materials they carried from the deeply weathered crystalline rocks of the Piedmont region.

In most places there is a distinct gradation from unaltered kaolin through bauxitic kaolin, in which there is a suggestion of pisolitic growth, to bauxite composed entirely of hard pisolites.

Bauxite is not a distinct mineral but rather a rock composed of at least two and possibly three hydrates of alumina, ranging from diaspore ($Al_2O_3H_2O$) though theoretical bauxite ($Al_2O_32H_2O$) to gibbsite ($Al_2O_33H_2O$), iron oxide, water, and silica, and more or less titanium oxide and clay.

The bauxite from all localities in the United States, though it may vary in chemical composition, is on the whole similar in general appearance, with the exception of the "granitic bauxite" of the Arkansas field. The greater part of the American bauxite appears to be made up of rounded pebblelike bodies set in a fine-grained matrix, which may also consist of small rounded particles or may be as fine grained as the finest clay. The pebble or pisolite form is so general that it is the conspicuous characteristic of American bauxite.

The pisolites vary in diameter from a small fraction of an inch to as much as 2 inches, but generally they range from one-fourth to three-fourths of an inch. They are not pebbles in the ordinary sense, as their shape is not due to rounding by running water. The pisolites, when sliced and examined under the microscope, are seen to be made up of concentric layers of amorphous material and are cut by veinlets of a crystalline aluminum mineral. In some deposits the pisolites are hard, in others soft, but it appears to be generally true that the hard pisolite ore is of better grade than the soft.

The matrix of the bauxite in some deposits is soft and clay-like, while in other places it is hard and flinty.

The color of American bauxites ranges from light cream through various shades of brown to a deep brownish red, depending on the quantity of iron contained. However, the color is not always a guide to the iron content for some brown or red bauxites are low in iron, the iron being only a stain on the surface and not penetrating the interior of the pisolite.

There is only one way to determine the value of bauxite and that is by chemical analysis, which should show total silica, alumina, titanium oxide, iron oxide, and water. Bauxites of commercial grade should carry at least 52 per cent alumina, though much of that shipped contains from 58 to 65 per cent Al_2O_3, and some material as low as 42 per cent Al_2O_3 is mixed with higher grade ore to bring the average up. Silica and iron should not run above 15 per cent, and the better grades of

bauxite contain as low as 1 per cent iron and 3 to 5 per cent silica. Titanium is objectionable, and the content should be below 2 per cent, though much of the central-Georgia bauxite carries nearly 3 per cent TiO_2. The combined water of American bauxites ranges from 15 to 33 per cent. Some of the Arkansas and central-Georgia bauxites are particularly low in iron, titanium, and silica, and are used in the preparation of alumina from which aluminium is made.

A few characteristics, which indicate in a general way the quality of bauxite, may be mentioned, though it is recognized that none of them are dependable. In general, bauxite of fair grade will not show the marks of a hammer when it is hit a glancing blow, though some bauxite has been shipped which can be cut with the hammer. Good bauxite, which has been dried either in the open or in kilns, when thrown on a hard floor has a distinct rattle which bauxitic clay does not have. The pisolites of the lighter-colored bauxites of the central-Georgia field have a peculiar brownish-buff color and look something like horn or flint; they ordinarily can not be broken or marked with the finger nail in bauxites of good grade.

Some measure of the relative quality of dried bauxite can be had by grinding a sample in an agate mortar for half a minute. A bauxite of good grade will be found hard to grind and will stick to the mortar with such tenacity that it will have to be scoured out; a poor bauxite or bauxite clay will grind much more easily and will stick very little, if at all; and clay or kaolin grinds with ease and does not stick to the mortar. Similar results are found if the sample is rubbed on glass and the glass will not be scratched by even high-grade bauxite.

UNITED STATES DEPOSITS.

Arkansas field.—The Arkansas deposits are closely associated with syenitic igneous rocks which outcrop in Saline and Pulaski counties. A large part of the bauxite, according to Mead,* is clearly the result of surface alteration of the syenite in place, though some deposits of transported and reconcentrated bauxites are found in the sedimentary rocks around the syenite center. The syenite first alters to kaolin, which on

*Mead, W. —., The occurrence and origin of the bauxite deposits of Arkansas: Econ. Geology, vol. 10, No. 1, pp. 28-54, 1915.

further action of the surface waters loses silica and changes to bauxite of the "granitic" type, in which the original texture of the syenite is preserved. Further action similar to concretionary growth results in the formation of the usual pisolitic variety of bauxite.

The deposits in Pulaski and Saline counties have been extensively worked by the American Bauxite Co., the Republic Mining & Manufacturing Co., the National Bauxite Co., and the Globe Bauxite Co. Recently the American Bauxite Co. has built a loading station at Bauxippi, Ark., to transship bauxite from cars to river boats for transportation to its plant at East St. Louis.

North Georgia-Alabama-Tennessee field.—In Cherokee County, northeastern Alabama, near Rock Run and Piedmont; in Floyd County, northwestern Georgia, near Rome and Cave Springs; and also near Chattanooga and Keensburg, Tenn., there are large pocket deposits of bauxite which have been worked for a number of years. Some of the pockets have been worked out; others are still in operation; and new deposits are still being found.

The pockets are generally lenticular, ranging from 25 to 300 feet in greatest horizontal dimensions and varying in depth, though the depth is usually comparable to the larger horizontal axis. The pockets are disposed along fault lines, which are clearly marked. Most of them are at the base of grayish quartzite ridges and at the edge of the red clay areas that have resulted from the weathering of the Knox dolomite. The presence of bauxite is usually indicated on the surface by "dornicks" or rounded bowlders of pisolitic bauxite, which are often uncovered in the cultivation of fields.

Not all of the material in the pockets is bauxite, as irregular masses of red and white kaolin are found mixed with the bauxite; but these materials can be separated in mining, as the ore is usually distinctly pisolitic and harder than the kaolin. In some deposits the pisolites are harder than the matrix of the bauxite, and the reverse conditions hold in other places.

All the bauxite mined by the Republic Mining & Manufacturing Co. is kiln-dried before shipment, but none of the other operators dry their ore. Mining at all properties is by hand methods and a number of the properties have no power-driven

equipment, though several of the larger pits are equipped with steam pumps and engines for operating the incline plain hoists. A little powder is used to loosen the hard bauxite for ease in picking.

The deposits near Piedmont, Ala., have not been worked for a few years; but the National Bauxite Co. is reported to be reopening the Snider pit about 7 miles north of that place. Near Rock Run, Ala., the Republic Mining & Manufacturing Co. is working several deposits; the largest about 1½ miles east of the town is a pocket about 300 feet in diameter, which is still producing at a depth of 92 feet.

It is reported that bauxite deposits near Fort Payne, DeKalb County, Ala., will be on a producing basis in the near future.

Deposits near Cave Springs, Ga., are under development by the Republic Mining & Manufacturing Co. and Asbury & Sparks, and the first-named company is also shipping from the Booger-Hollow pit near Six Mile.

In the Hermitage area north of Rome, Ga., the Republic Mining & Manufacturing Co. is shipping from a number of deposits on the east side of Armstrong Mountain, near Hermitage, and Asbury & Sparks are developing a pocket about 2½ miles south-southeast of Pinson station.

The bauxite deposits on Missionary Ridge, near Chattanooga, Tenn., were not extensively worked during 1916, though a small output was made. The Carter County deposits in northeastern Tennessee were under development throughout the year. The deposits at both places are quite similar to those near Rome and Cave Springs.

*Central Georgia field.**—The first discovery of bauxite in central Georgia was made in Wilkinson County, and for a time the chief bauxite production of the field was made from deposits near McIntyre and Toomsboro. This area has been gradually extended so that at present bauxite is known to occur westward nearly to Dry Branch, northward to Stephens Potters, southward to Irwinton, and eastward to Oconee River. Deposits near Gordon, McIntyre, Toomsboro, and Irwinton are now under development.

These flat-lying lenticular deposits are at all places associated with nearly white sedimentary kaolins of Upper Cretaceous

*Shearer, H. K., A report on the bauxite and fuller's earth of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 31, pp. 19-140, 1917.

age. In most places the bauxite lies above the kaolin and the base of the bauxite is not distinct, as it grades into unaltered kaolin. At a few places kaolin overlies a bed of bauxite, into which it grades. Whether the bauxite was deposited as such or is an alteration of the kaolin of recent occurrence is a moot question, but the evidence seems to favor the hypothesis that the bauxite was formed by alteration of the kaolin subsequent to its deposition. The principal operators in this field are the Republic Mining & Manufacturing Co., National Bauxite Co., General Bauxite Co., and the Columbia Kaolin & Aluminum Co.

Since the first bauxite deposits were found in central Georgia, a large field has been opened near Andersonville, in Sumter County, and within the last two years promising deposits have been found in the adjoining parts of Macon and Schley counties. The deposits in this area are similar to those in Wilkinson County in distribution and character, but are found in younger kaolins. These kaolins are Tertiary and probably of the Midway or Claiborne (Eocene) age. The chief operators are the Republic Mining & Manufacturing Co., Kalbfleisch Corporation, Easterlin, and Maynard & Simmons.

Within the last year developments seem to point to a westward extension of the bauxite deposits into Randolph and Stewart counties in western Georgia and possibly into eastern Alabama on a line with known occurrences in adjacent parts of Georgia.

An unusual deposit of bauxite, about 2 miles west of Warm Springs or Bullochville, in Merriwether County, has been worked for a few years. At this place beds of kaolin, which dip steeply north, are exposed by the workings. Two of the beds have been altered to bauxite, one a light-colored variety of good grade from which shipments have been made, the other a dark-red variety which has not been mined. The deposit was operated by the Republic Mining & Manufacturing Co.

ALUMINUM.

DOMESTIC PRODUCTION.

The value of primary aluminum produced in the United States in 1916 was $33,900,000, an increase of 108 per cent

over the value of the output in 1915. The value of the total domestic production of new metal and metal produced from scrap in 1916 was $57,330,200, as compared with $22,082,100 in 1915.

MARKET AND PRICES OF ALUMINUM.

In the United States the quoted prices for primary or "virgin" aluminum† ranged from a low of 55 cents a pound in January to a high of 65.12 cents a pound in November, the average for the year being 60.71 cents a pound, as compared with 33.98 cents in 1915. These prices are for small lots and immediate delivery, offered in the open market, and must not be taken to represent the price received by the single producer of primary aluminum in this country. It is reported,† apparently on good authority, that the contract prices of the Aluminum Co. of America to regular consumers ranged from 31 to 37 cents a pound in 1916, as compared with 20 to 31 cents a pound in 1915. The demand for aluminum was very large during 1916, particularly for war materials of various sorts, and it is highly probable that the demands in the near future will be increased considerably.

USES OF ALUMINUM.

No new uses of aluminum of importance were reported during 1916. Apparently the use of aluminum powder in the high explosive "ammonal" greatly increased, though there was a tendency to a restriction of the use of this form of aluminum for precipitation of silver from cyanide solution in metallurgic practice. Aluminum foil has not entirely replaced tin and lead foil for the various uses to which those materials are put.

A large part of the domestic consumption of aluminum is in the form of castings and drawn and pressed ware, which enter into almost every industry. The more important consumption, at present, appears to be in airplanes, automobiles, and war munitions, though immense quantities of cast and pressed aluminum utensils for war, household, and industrial uses are consumed.

Aluminum wire for the transmission of electricity has been replaced by copper to a considerable extent, apparently not so

†Eng. and Min. Jour., vol. 103, p. 29; also Metal Industry, vol. 15, p. 11, 1917.

much because of failure of aluminum as because of the high price of the metal as compared with copper.

Patents for many inventions relating to aluminum—various alloys, methods of fabrication, soldering, and purification of scrap aluminum—have been issued during the last year, copies of which may be obtained from the United States Patent Office.

Other Bauxite Products.

Nearly 70 per cent of the domestic output of bauxite in 1916 went into aluminum, but manufacturers of aluminum salts used nearly 19 per cent; apparently 8 per cent was consumed in the manufacture of bauxite abrasives; and 3 per cent was used by makers of "high-alumina refractories," sometimes called bauxite brick.

Within the last two years many foreign and domestic patents have been issued relating to the use of bauxite in the fixation of nitrogen, the manufacture of aluminum salts, and the fabrication of abrasives and refractories. Copies of these patents may be obtained from the United States Patent Office, Washington, D. C.

ALUMINUM SALTS.

The principal aluminum salts made in the United States are alumina, alums, usually ammonium and sodium alums, aluminum sulphate, and aluminum chloride. Alumina is largely consumed in the manufacture of aluminum and no figures of domestic production are available. Alums of various qualities are produced at 9 plants in the eastern United States, the total production of alum in 1916 being 27,257 short tons, valued at $1,177,881, an increase over 1915 of approximately 10 per cent in quantity and of 68 per cent in value.

Aluminum sulphate is made at 18 plants, 6 of which are located at municipal or industrial waterworks, which consume their entire output. The total quantity of aluminum sulphate produced in the United States in 1916 was 153,860 short tons, of which 6,037 short tons did not enter the market but was used for water purification at the place of manufacture. The quantity of domestic aluminum sulphate which entered the market,

147,823 short tons, was less than the quantity in 1915 by 12 per cent, and the total domestic production fell off about 9 per cent. The value of the total production of aluminum sulphate in 1916 was $4,410,741, an increase of nearly 37 per cent over the value of the greater production of 1915.

Aluminum chloride is used for various purposes, among which may be mentioned the refining of mineral oils. This salt was produced at 5 plants in 1916, the total output reported to the Geological Survey being 3,322 short tons, valued at $234,423, or approximately $70 a short ton. This is the first time statistics of production of aluminum chloride have been collected by the Geological Survey.

BAUXITE ABRASIVES.

Bauxite abrasives sold under various trade names, such as alundum, aloxite, carborundum, exolon, and lionite, are made by fusing bauxite in an electric furnace. The fused product is broken, sized, and put into shape for market. Some grades of nearly white artificial aluminum abrasives are believed to be made from alumina. These products are sold in the form of powders, cloth, grinding stones, and wheels of various shapes for a multitude of uses.

The total production of artificial abrasives made from bauxite in 1916 was 30,708 short tons, valued at $2,139,230. Statistics of these products have not been published separately heretofore by the Geological Survey.

HIGH-ALUMINA REFRACTORIES.

There are two classes of high-alumina refractories now on the market. One commonly called bauxite brick is made by mixing various proportions of calcined bauxite or high-alumina clay with a bonding material such as fire clay, sodium silicate, or lime. The material is shaped and then burned at a high temperature in down draft kilns. Refractories of this character are being made by Laclede Christy Clay Products Co., Harbison Walker Refractories Co., Charles Taylor & Sons, and the Massillon Stone & Fire Brick Co. Not all the refractories made by these companies are sold as bauxite brick, and in fact some do not contain bauxite. It would appear that any refractory brick containing 58 per cent or more of alumina should

be included in a statement of the production of high-alumina refractories.

From the best information available to the Geological Survey it would appear that in 1916 bauxite refractories containing 58 per cent or more of alumina to the amount of over 1,000,000 brick, 2½ by 4½ by 9 inches in size, were sold. As has been stated, the refractories are not all sold as brick, but the total quantity is reduced to a comparable figure for publication. The price of these refractories varied from $175 to $380 a thousand, the price apparently depending on the quality of the product.

Refractory brick containing from 45 to 58 per cent alumina were sold in large quantities, the output in 1916 being probably 2,000,000 brick, at prices ranging from $50 upward a thousand.

The second class of high-alumina refractories consists of those made by the electric fusing of bauxite, the molten mass being cast in desired shapes. No information is available concerning the production of this class of refractory, which is being made by some of the companies that make artificial abrasives.

The use of high-alumina refractories seems to be expanding, particularly in the construction of copper, iron, and lead furnaces and of cement kilns.

CEMENT.

EUGENE A. SMITH.

PORTLAND CEMENT.

RESOURCES.

ALABAMA contains large supplies of limestone, chalk, clay and shale well adapted to Portland cement manufacture, and widely distributed throughout the State. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage

of location was immensely increased with the opening of the Panama Canal for cement plants located in Alabama are more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the State lie so close to each other, and above all so close to the great coal mines which must supply the fuel, that the establishment of Portland cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our State beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent lime carbonate and 25 per cent of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance.

The limestone formations in North Alabama which can supply the stone adapted for use in cement manufacture are the Trenton or Pelham limestone and the Bangor or Subcarboniferous. In close proximity to both these limestone formations are the shales of the Clinton, Subcarboniferous and Coal Measures.

At the present time there are two cement plants in North Alabama, namely, the Standard Portland Cement Co., located at Leeds in Jefferson County, and the Coosa Portland Cement Co., located at Ragland in St. Clair County. Both of these plants make use of the hard Trenton limestone, and the Standard Cement Co., according to Burchard of the U. S. Geological Survey, uses the shale of the Clinton formation whilst the Ragland Company makes use of the shales of the Coal Measures. Up to the present time no establishment is utilizing the Bangor limestone.

In Middle Alabama the soft, chalky Cretaceous limestone of the Selma Chalk, is the material utilized by the Alabama Portland Cement Co., at Spocari, near Demopolis. The same Company makes use of residual clays overlying and derived from

the weathering of the Selma Chalk. During 1915, and since, there was no production from the Demopolis plant.

In Southern Alabama the St. Stephens limestone outcropping east and west across the State, furnishes excellent material for Portland cement manufacture, using either residual clays from decomposition of the limestone, or the clays of the Grand Gulf formation which are almost everywhere in close proximity to the limestone.

Puzzolan Cement.

During the past seven years only one establishment in Alabama, the Southern Cement Company, North Birmingham, has been engaged in the manufacture of slag cement, using the material from the furnaces about Birmingham. The production is included in the returns for Portland cement and cannot be given separately.

Owing to the fact that there was in Alabama in 1916 only one producer of puzzolan cement, and not more than two operating plants in the Portland cement industry, it is necessary to combine the productions of the two industries in order to avoid publishing figures which were given to the Survey in confidence. The tabular results of such a combination are, however, necessarily inconsistent and not to be taken too literally, since the weights per barrel of the two kinds of cement vary.

The total quantity of Portland and puzzolan cement shipped to market in Alabama in 1916, was 1,442,475 barrels, valued at $1,410,104, as compared with 1,114,386 barrels in 1915, valued at $891,473, or an increase in quantity of 328,089 barrels, and an increase in value of $518,631.

Below are given in tabular form the foregoing figures:

Quantity and value of Portland and puzzolan cement marketed in Alabama in 1915 and 1916.

	No. of Producers	Quantity (Bbls.)	Value
1915	3	1,114,386	$891,473
1916	3	1,442,475	1,410,104
Increase		328,089	518,631
Per cent of increase		29.4	58.2

Recovery of Potash From Portland Cement Materials.

It has been noticed that the flue dust in a cement plant often contains notable percentage of potash, and efforts have been made to utilize this dust in the extraction of potash. Flue dust from the Standard Cement Plant shows 2½ per cent and above potash, and it is in contemplation to utilize this, and the suggestion is also made to use feldspar in the manufacture. Up to the present time, however, there has been no commercial production of any potash from this source.

CLAY AND CLAY PRODUCTS.

Clay.

Jefferson Middleton and Eugene A. Smith.

CLAY available for the manufacture of clay products is one of the most widely distributed of our minerals. Hence there are clay-working plants scattered over every State and Territory in the Union. Miners of the low-grade clays are usually also the manufacturers, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer buys and does not mine the clay he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

The total amount of clay mined in Alabama and sold as such in 1916, was 41,479 short tons valued at $51,053. This was an increase in quantity of 9,609 short tons or 30.2 per cent, and of $15,821 or 44.9 per cent in value as compared with 1915.

Below is a table giving the production and value of clay mined and sold in Alabama from 1908 to 1916 inclusive, and a comparison of the production of 1915 and 1916:

Production of clay in Alabama from 1908 to 1916 inclusive, and a comparison of the production in 1915 and 1916.

YEAR	FIRE CLAY		MISCELLANEOUS CLAY		TOTAL	
	Quantity Short Tons	Value.	Quantity Short Tons	Value.	Quantity Short Tons	Value
1908	68,289	$48,983	24,000	$12,000	92,289	$60,983
1909	45,137	35,345	18,271	5,587	63,408	40,932
1910	54,482	32,395	20,600	5,650	75,082	38,045
1911	35,203	29,909	.....	.....	35,203	29,909
1912	38,552	31,414	4,500	2,000	43,052	33,414
1913	49,901	53,269	*	*	49,901	53.419
1914	27,973	34,607	.....	.....	27,973	34,607
1915	31,520	34,882	*	*	31,870	35,232
1916	40,235	50,618	1,244	435	41,479	51,053
Increase	8,715	15,736	.....	.....	9,609	15,821
Percentage	27.6	45.3	.....	.....	30.2	44.9

*Not divulged but included in total.

In 1915 the average value of the fire clay of Alabama was $1.11 per short ton, and the value of the fire clay production of the State was 1.58 per cent of the total value of the United States production. In 1916 the average value of the Alabama fire clay was $1.26 per short ton, and the value of the Alabama product was 1.37 per cent of the total value of the fire clay produced in the United States.

Clay Products.

The State of Alabama is rich in clays of many kinds, yet its rank as a clay-working State is low, being twenty-fifth in 1916. Its clay products in that year reported by 57 operators were valued at $1,520,301—brick and tile, $1,497,496; pottery, $22,805—an increase of $327,279, or more than 27 per cent. Alabama ranked third in value of silica brick and fourth in its output, and eighth in quantity and tenth in value of vitrified brick or block. Its principal clay product was common brick, valued at $497,446, or 33 per cent of the State total, an increase of $115,354. The quantity of common brick marketed in 1916 was 85,655,000 brick, an increase of 14,974,000 brick. Vitrified brick or block was Alabama's clay product of second value;

25,143,000 brick valued at $311,317, a decrease from 1915 of 3,605,000 in quantity and of $63,070 in value.

Pottery products of Alabama are of minor importance, constituting less than 2 per cent of the value of the clay products of the State. Fire brick, including silica fire brick, was the leading product in Alabama and constituted over a third of the value of the clay products of the State.

Jefferson County was the principal clay-working county, and reported a production valued at $1,060,682, or 70 per cent of the State's total, and an increase of $245,344 compared with 1915. Nearly all of the fire brick and vitrified brick or block produced in the State came from Jefferson County. The principal common brick-producing counties, named in the order of the value of their output were Jefferson, Montgomery, and Talladega.

In tabular form these statistics are given below:

Clay products of Alabama, 1912-1916.

PRODUCT.	1912	1913	1914	1915	1916
Brick:					
Common—					
Quantity	136,989,000	130,923,000	110,731,000	70,681,000	85,655,000
Value	$759,409	$730,148	$638,666	$382,092	$497,446
Average per M.	$5.54	$5.58	$5.77	$5.41	$5.81
Vitrified—					
Quantity	26,480,000	24,183,000	18,679,000	29,018,000	25,143,000
Value	$353,303	$361,722	$248,525	$374,387	$311,317
Average per M.	$13.34	$14.96	$13.31	$12.90	$12.38
Front—					
Quantity	10,629,000	(*)	(*)	5,815,000	6,968,000
Value	$132,033	(*)	(*)	$58,212	$77,470
Average per M.	$12.42	$15.29	$11.42	$10.01	$11.12
Fancy, value	(*)	.....	(*)	.....	.....
Fire, value	$240,434	(*)	$167,021	$145,535	$278,749
Draintile, value	$5,465	$10,802	$6,838	$9,330	(*)
Sewer pipe, value	(*)	(*)	(*)	(*)	(*)
Fireproofing, value	(*)	(*)	(*)	$62,114	$80,523
Tile, not drain, value	.....	(*)	.....	.....	.....
Pottery:					
Red earthenware, including turpentine cups, value	$10,990	$11,164	$4,800	$6,741	$13,551
Stoneware and yellow and Rockingham ware, value	$11,223	$8,994	$11,742	$8,556	$9,254
Miscellaneous,† value	$422,322	$968,751	$496,431	$146,055	$251,991
Total value	$1,935,179	$2,091,581	$1,574,023	$1,193,022	$1,520,301
Number of active firms reporting	74	68	70	65	57
Rank of State	17	16	20	24	25

*Included in "Miscellaneous." †Miscellaneous includes drain tile, sewer pipe, stove lining and silica brick.

Value of the clay products of Alabama in 1915 and 1916, with increase.

	BRICK AND TILE	POTTERY	TOTAL
1915	$1,177,725	$15,297	$1,193,022
1916	1,497,496	22,805	1,520,301
Increase:			
Value	319,771	7,508	327,279
Per cent	27.15	49.15	27.43

Pottery products of Alabama are of minor importance, constituting less than 2 per cent of the value of the clay products. Production was reported in 1916 by nine firms. The output was valued at $22,805, an increase of $7,608, or 49.1 per cent as compared with 1915. The products consisted of stone ware and yellow and Rockingham ware, and red earthen ware, including turpentine cups, etc. The latter represents a very notable proportion of the total product. The rank of Alabama in the pottery industry in 1916 was 16.

Comparison of pottery products in 1915 and 1916.

KIND	1915	1916	Increase	Percentage
Red earthenware*	$6,741	$13,551	$6,810	101.02
Stoneware and Rockingham ware	8,556	9,254	$698	8.04
Total	$15,297	$22,805	$7,508	49.08

*Including turpentine cups, vases, etc.

COAL.

E. W. Parker and C. E. Lesher.

Introductory.

THE great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production is the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 81 per cent of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby and Bibb counties. There are many workable beds, and the total quantity of coal in the basin is large. The production is something over 17 per cent of the total for the State.

Graphite Development Co., the Hood Graves Co., the Norway Graphite Co. (property in sec. 22, T. 20 S., R. 6 E.), and the Superior Flake Graphite Co. (property in secs. 15, 21, and 22, T. 19 S., R. 8 E.).

Coosa County.

The graphite-bearing belt of Coosa County extends from Goodwater southwestward to Coosa River. It is only in the Goodwater region, however, that active work is in progress. No production was made from this district during 1916, but in April, 1917, one company had a mill in full operation, another was building its mill, and three more contemplated beginning construction within a short time.

The Ceylon Co. (office, Birmingham, Ala.) has erected a large mill in the NE. ¼ sec. 16, T. 24 W., R. 19 E. A special process is used, the details of which are not made public. The graphite-bearing schist is said to average about 150 feet in width and has been prospected for 1,000 feet along the strike. The strike is about N. 35° E. and the dip is 55°-60° SE. The outcrop follows the crest of a prominent ridge, on the north side of which the mill has been built. An open cut is being carried across the deposit to the level of the ore bin, and it is planned to work back from this toward the mill, thus gaining the advantage of working against the dip. The ore grades off on the walls into leaner quartz schist containing small bands of graphitic schist. The graphite is shipped from Hollins, a station on the Central of Georgia Railway about 7 miles west of Goodwater.

The Goodwater Graphite Co. (office, Goodwater, Ala.) is erecting a mill about 1½ miles northwest of Goodwater and expects to be ready for operation by June 1, 1917. The ore will be crushed by a series of jaw crushers and rolls and circular water-flotation machines will be used for concentration. The graphite-bearing schist, which has a width of about 40 feet, strikes N. 70° E. and dips about 25° SE.

The Graphite Co. of America (office, Birmingham, Ala.) is planning to develop a large area of about 2 miles northwest of Goodwater, between the property of the Goodwater Graphite Co. and the Hatchet Creek. Graphite-bearing schist has been exposed in several pits and trenches. The strike is about N. 70°

E. and the dip averages 45° SE. It is planned to use a dry process in the mill.

The Royal Graphite Co. and the United Graphite Co. are also prospecting lands in the vicinity of Goodwater.

Chilton County.

The only plant in operation in Chilton County is the Flaketown Graphite Co., about 3½ miles northeast of Mountain Creek station on the Louisville & Nashville Railroad. The property was visited by Mr. Bastin in May, 1916, and will be described at length in the forthcoming bulletin on graphite deposits of the United States. A special process is employed at the mill, the details of which are not made public.

FUTURE OF THE ALABAMA GRAPHITE INDUSTRY.

The large number of new companies beginning operations at the present time naturally makes it of importance to consider the probable effect of the future increased production upon the market. If all the mills in the Alabama field are able to operate at anything like their expected capacity, the result will be an annual production of flake graphite of approximately 30,000,000 pounds, about 15 times the production of Alabama in 1913, and nearly equal to the entire importation from Ceylon for that year. As long as the war continues a largely increased production can probably be absorbed by crucible makers and other users of crystalline graphite, but if the graphite from Ceylon and Madagascar continues to enter the market freely, the price of domestic graphite will necessarily be reduced with the increase in production. On the other hand, mining conditions in Alabama are very favorable, the mining costs are low, and new developments in concentration and finishing will probably result in a larger percentage of good flake in the finished product and a higher saving of graphite of all grades. Costs of mining and milling at an efficiently managed plant should not exceed $50 a ton of concentrates produced, or about 2½ cents a pound for the finished product, and even with prices as low as 5 cents a pound for No. 1 flake, 3 cents for No. 2, and 1½ cents for dust, there should still be a possibility of profit. A recent article by Prouty* contains an interesting dis-

*Prouty, W. F., Extent and development of flake graphite resources of Alabama; Manufacturers' Rec., Apr. 19, 1917, pp. 66-67.

cussion of costs of production of graphite in Alabama. It is of course idle to speculate on the possible duration of present conditions, and the situation may be summed up by saying that as long as the present demand for crucibles in the manufacture of munitions continues, the plants in operation should all be able to make profits, and even with the expected drop in prices after the war the most favorably situated and efficiently managed plants should continue to be profitable.

With a return of peace, however, operators will face an unfavorable condition caused by a decreased market and large increase in production.

IRON ORE.

ERNEST F. BURCHARD.

EUGENE A. SMITH.

ESSENTIAL FEATURES OF AN IRON-ORE DEPOSIT.

THE war in Europe has greatly stimulated prospecting for minerals and ores in the United States, and as a result of this prospecting many specimens are sent to the United States Geological Survey for identification. The majority of specimens are readily identified at sight; some require a brief visual examination; others require more elaborate physical or chemical tests. The Survey is not permitted to make chemical analyses or assays of minerals or ores for private persons or corporations, but it is compatible with the duties of the Survey to inspect a specimen and to state, if possible, what it is; to give an offhand opinion as to whether or not the material constitutes an ore; and to recommend or discourage further expense in prospecting it or in having analyses or assays made.

Iron minerals are among the most common and are abundantly distributed, and naturally many specimens are received by the Geological Survey. It is therefore believed that a few notes on these minerals and on the requirements of a deposit in order to render it of commercial importance may be of interest to those making inquiries on the subject. The classes

of iron minerals that constitute a source of iron ore are oxides and carbonates. There are three general varieties of oxides, viz, hematite, brown ore, and magnetite. Brief descriptions of each follow.

SOURCE OF IRON.

The forms in which iron occurs in the earth in combination with other substances are very numerous. Nearly all hard rocks, as well as the softer soils, sands, clays, and many "mineral" waters contain iron in some combination and in varied proportions. Iron is seldom found "native"—that is, occurring in the earth in the form of metallic iron. When it is found in the metallic state, as, for instance, in meteorites that have fallen from space upon the earth, it is not in quantities large enough to be of commercial value. The combination of iron with one or more other substances is called an iron compound, or iron mineral, and where the iron compounds are such that iron can easily be extracted from them and they occur in such abundance that they can be mined profitably these iron compounds are called iron ores.

Iron in combination with other substances is regarded next to aluminum, a metal contained in clay, as the most abundant metal. Thus, according to recent calculations,* metallic iron forms about 4.50 per cent of the rock crust of the earth, compared with 7.85 per cent for aluminum.

IRON ORE.

There are four important types of ores of iron—red iron ore, or hematite; brown ore, or limonite; magnetic ore, or magnetite; and carbonate ore, or siderite—although there are hundreds of minerals in which iron is a constituent. These types of ore may easily be remembered through their most common colors, which are, respectively, red, brown, black and grayish.

Hematite.

Hematite includes all varieties of the anhydrous sesquioxide (Fe_2O_3). This is known locally as red hematite, specular ore,

*Clarke, F. W., The data of geochemistry, 3d ed.; U. S. Geol. Survey Bull. 616, p. 34, 1916.

gray ore, fossil ore, oolitic ore, etc. Hematite is composed of two parts of the metal iron united with three parts of oxygen. Iron forms 70 per cent by weight of pure hematite and oxygen 30 per cent, and the mineral is known chemically as the sexquioxide of iron or ferric oxide. Hematite may occur as a rock in beds, in veins, or in masses of irregular shape, and it may occur in a soft, earthy state, or as a loose debris in the soil, and yet in all these forms be profitably mined if the controlling conditions are favorable. Hematite is easily recognized in the hand specimen by its colors (red to steel-gray and black) and the red mark or streak it leaves when drawn across a rough surface and by its high specific gravity or superior weight as compared with the weight of pieces of ordinary red rock or red clay of equal size. The old-fashioned "keel" or red chalkstone formerly used by carpenters for marking lumber is a form of hematite. Finely ground hematite is used in the manufacture of red paint and other red coloring materials.

Hematite is by far the most important iron ore. It is found in great abundance in the United States in the vicinity of Lake Superior in Minnesota, Michigan, and Wisconsin; in central New York; in the Appalachian region of Alabama, Georgia, Tennessee, and Virginia; and in eastern Wyoming. It also occurs in lesser quantities in Pennsylvania, Maryland, Kentucky, eastern Wisconsin, Utah, and California. (E. F. B.)

All the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys, being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphree's Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary

greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Fort Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop on Red Mountain is not too great for shaft mining.

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

In 1913 the Gulf States Steel Company acquired about 1,500 acres of land upon which the drill hole above mentioned was located. They have since sunk a double track slope to the ore. In time this is likely to be the largest producing mine in the State.

Another drill hole was put down in Shades Valley in 1913, in Section 19, T. 19, R. 3 W., but the record was not available for publication at the present time.

The hematite production in Alabama in 1916 was 5,672,005 long tons, as against 4,374,309 tons in 1915, an increase of 1,297,696 tons or 29.44 per cent. This 1916 production of hematite is 84.05 per cent of the total iron ore production of the State, and 7.55 per cent of the total iron ore production of the United States.

The average price of hematite in Alabama in 1915 was $1.25; in 1916, $1.52. (E. A. S.)

Brown Ore.

Brown ore is composed of iron, oxygen, and water, and in a general way might be said to be hematite combined with water. A general formula may be expressed by $nFe_2O_3nH_2O$. Brown ore may contain water in several proportions so that the percentage of iron likewise varies, but the latter ranges generally from 52 to 66 per cent in the pure mineral. Thus brown ore does not contain quite as high a percentage of iron as hematite, and therefore it can not yield so much metal. One of the most common brown ore minerals is known as limonite ($2Fe_2O_3 3H_2O$), and this contains 59.9 per cent of iron, 25.7 per cent of oxygen, and14.4 per cent of water. Brown ore occurs in a large variety of forms, nearly all of which have in common a characteristically yellowish-brown to chocolate-brown color and yield a brown streak and powder. Exceptionally certain hydrated sesquioxides of iron may appear bright red, and some may show black surfaces; but these exceptional forms are generally to be found closely associated with a mass of ordinary brown ore, and familiarity with the deposits soon dispels any perplexity regarding the nature of the ore on the part of persons mining or handling it. The specific gravity of brown ore is also higher than that of ordinary rock. Brown ore commonly occurs in irregular masses and lumps, and as ore gravel and sand, embedded in banks of clay, sand, and stone gravel. The ore in places lies in layers, but more commonly in irregular pockets, separated by barren clay, sand, and stone gravel. In places the ore takes the form of hollow concretions or "pots" which may contain some loose sand or clay in the interior, and also it appears as honeycombed masses ramifying through the inclosing ore-bearing ground.

Limonite is used chiefly as a source of iron, but the brown and yellow forms, called ocher, are used for paint and for making oil-cloth and linoleum. A porous variety of limonite is used in the purification of illuminating gas, and also as a contact material in the production of hydrogen gas for inflation of dirigible balloons and for precipitation of fats from oils. Many iron compounds are used in medicines.

Deposits of brown iron ore are common in many portions of the eastern United States, particularly in valleys underlain by limestone. Some of the best-known deposits are in Con-

necticut, Vermont, Pennsylvania, Virginia, Tennessee, Alabama, northeastern Texas, and in Iowa and Wisconsin near Mississippi River. (E. F. B.)

This ore, the second in importance in the State, and third in the United States, furnishes only 1.43 per cent of the total iron ore production of the United States, and 15.94 per cent of the iron ore production of the State in 1916. The entire brown ore production of the United States in 1916 was 1,904,484 long tons of which Alabama contributed 1,075,896 tons or 56.49 per cent, and the State holds accordingly the first rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in

the different ore banks, but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the State, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The limonite or brown ore production of Alabama in 1916 was 1,075,896 long tons as against 935,045 tons in 1915, an increase of 140,851 tons or 15.06 per cent.

The average price per long ton of brown ore marketed in Alabama in 1916 was $1.97, as against $1.68 in 1915. (E. A. S.)

Magnetite.

Magnetite (Fe_3O_4) is a black ore of iron which is attracted by the magnet. It contains iron and oxygen in the proportion of 3 parts of iron to 4 parts of oxygen, which by weight gives 72.4 per cent of iron and 27.6 per cent of oxygen. Magnetite thus contains the highest percentage of iron of the ores thus far mentioned, and in fact, of all the iron ores. Magnetite usually occurs in granular form and in crystals in veins in comparatively old crystalline rocks, although it may be found in comparatively young volcanic rock.

Magnetite is found in the United States in considerable quantities in the Adirondack region of New York, the Highlands of New Jersey, south Pennsylvania, eastern Wyoming, central Texas, southwestern Utah, and southern and northern California, and in small quantities in northern Michigan and in other States. It is used chiefly for the production if iron, but the less common variety known as lodestone, which is naturally magnetic, is sold at high prices for museum exhibits and for laboratory purposes. Magnetite is found in the form of sand along streams and on the shores of lakes or seas where it has been concentrated by the action of water. In this form

it has not proved of much commercial value as an ore of iron. (E. F. B.)

There has been no development of magnetic ore properly speaking, in Alabama. The gray ore of Talladega county which was mined to some extent a few years ago is essentially a hematite though some of it is slightly magnetic. There was no production of this ore in 1916. (E. A. S.)

Siderite.

Siderite, or iron carbonate ($FeCO_3$), is composed of 1 part of iron, 1 part of carbon, and 3 parts of oxygen and thus contains by weight where pure, approximately 48.3 per cent of iron, 10.3 per cent of carbon, and 41.4 per cent of oxygen. Iron carbonate ore where fresh is generally grayish in color, and occurs in nodules and in layers principally in sedimentary rocks that contain coal and lignite. The carbonate rapidly changes to brown ore on exposure to moist air. Siderite is known locally as spathic iron ore, kidney ore, clay ironstone, and blackband ore. Certain of these names are derived from the appearance of the ore in its different forms. For instance, a bed of carbonate ore that is found on the top of a coal bed in eastern Kentucky is striped with fine black carbonaceous bands.

Iron carbonate, in addition to being found in Kentucky, is common in southeastern Ohio, and occurs to a small extent in Pennsylvania, Alabama, Mississippi, and Texas.

IMPURITIES IN IRON ORE.

Consideration should be given to some of the principal impurities that are found in iron ores, first, in order to appreciate why a deposit of ore never yields the full percentage of iron that the predominant iron mineral contains, and, second, in order to show the relation of the ore to the operation of the blast furnace. Deposits of iron ore are generally so closely associated with the rocks which inclose them that they contain either mixed with the deposit or chemically combined within it some of the other rock-forming minerals. Among the most common of these minerals are silica, or sand; lime and magnesia, derived from limestone and dolomite; alumina, a clay mineral; manganese, a metal resembling iron; and small quan-

tities of sulphur and phosphorus. The presence of varying percentages of these and other minerals tends, of course, to reduce the percentage of metallic iron that the deposit will yield when mined, and they must be removed as far as possible in mining and almost completely in the process of making iron. Therefore, it is of the utmost importance that the average chemical composition of a deposit of iron ore be ascertained before an attempt is made to mine it.

The average composition may be termed the "quality" of the deposit. The quality is determined chiefly by two men, the prospector and the chemist. The prospector digs trenches and pits or drills holes in the ore and takes samples of it. The chemist analyzes these samples of ore in his laboratory, and finds the percentages of metallic iron, silica, lime, alumina, manganese, sulphur, phosphorus, water, etc., contained in average samples of the ore. On the quality of the ore depend the quantity of fluxing stone and fuel that must be used in the blast furnace and the kind of iron that can be produced.

RANGE IN COMPOSITION.

Many chemical analyses of commercial grades of these iron ores indicate a range in composition given in the following table:

Range in chemical composition of commercial grades of iron ore.

	Hematite Per cent	Brown ore Per cent	Magnetite Per cent	Carbonate Per cent
Metallic iron	25-65	35-58	48-70	25-48
Silica	2-35	3-23	0.6-20	1-23
Alumina	0.2-9	1.4-12	0.7-4.5	1-5
Lime	Trace to 27	0-0.6	0.5-4.5	0-7
Manganese	Trace to 5	0.16-5	0.07-1.5	0.1-4.7
Sulphur	Trace to 1.5	Trace to 0.5	Trace to 1.2	0.01-1.8
Phosphorus	0.013-1.23	0.04-1	Trace to 1.75	0.043-0.7
Titanium	0-0.9	.....	0-1.5	0-0.04
Water	0.3-6	8.8-15	0.25-0.5	0-6.5

Under exceptional conditions ores are mined that contain more or less of the common constituents indicated above, but local conditions may determine whether an ore that falls within

the limits shown may be mined. For instance, hematite carrying as little as 2 per cent metallic iron would not be considered of value as an ore unless it contained enough lime to flux the silica and alumina present. Most southern red hematites contain considerable quantities of lime and are therefore workable where a highly siliceous ore carrying no more metallic iron and little lime would not be available under present conditions of metallurgic practice. At present ores averaging less than 25 per cent of metallic iron are not charged into blast furnaces in any considerable quantities, and ores as lean as this can not be used economically unless they carry more than enough lime to flux them and are used in connection with richer ore. In using limestone as a flux it would probably be more desirable to use a stone carrying 15 to 20 per cent of ferric oxide (10.5 to 14 per cent metallic iron) than one containing only 3 to 5 per cent ferric oxide, on account of the higher iron yield of the former. Nevertheless, the more ferruginous limestone would not commercially be classed as an ore; yet a bed carrying 35.5 per cent ferric oxide (25 per cent metallic iron), although in itself not quite rich enough, might be conceded to be an "ore." There are other exceptions to be noted in this table. Some deposits of nontitaniferous magnetite can be so treated by means of crushing and electromagnetic separation that, although they may contain as little as 25 per cent metallic iron, they will yield a high grade concentrate. Such ores may be used to advantage, especially where they can be concentrated along with richer grades. Considerable phosphorus is present in the mineral apatite associated with Adirondack magnetite; and this and silica are largely eliminated by electromagnetic concentration. The possibilities of various methods of concentration or beneficiation must therefore be taken into consideration in appraising an ore, and this involves consideration of the physical as well as the chemical character of the ore. The content of water is a widely variable item. Some ores contain much absorbed water, which can be driven off by drying. Hematite is found in all stages of hydration, and thus may contain water up to the point where it should really be classed as a brown ore. Hydrated ores are thus concentrated by heating to drive off the chemically combined water. Carbonate ores are calcined to drive off both carbon dioxide and water. Some iron oxides

are subjected to a partial reduction and are thus rendered magnetic, and the separation of nonmetallic impurities is thereby greatly facilitated. One brown-ore deposit that averages in the raw state not more than 30 per cent of metallic iron is thus through a complicated process of beneficiation rendered of commercial value. The question of beneficiation is therefore becoming increasingly important; and there must also be taken into consideration the proximity to transportation, and to blast furnaces, to water-power sites for possible electric reduction, as well as the prevailing conditions of the market. The laws of supply and demand that prevail in 1917 make available lower grades of ore than would be considered desirable in times when low prices for iron and steel are current. The question of quantity available is also of importance, for iron ore is so bulky a product, is relatively so low in value even at the best, and involves so large an expenditure for equipment for mining on a satisfactory scale that any deposit should contain several years' supply to be worthy of development.

To summarize, then, the ore should occur in a deposit containing several hundred thousand tons of merchantable grade, susceptible of economical mining and convenient to transportation and markets, if its development is to be seriously considered. (E. F. B.)

Details of Iron Ore Production In Alabama, 1915-1916.

The following tables show details concerning the production of iron ore in the State, together with the rank of the State in mined and marketed iron ore in 1915 and 1916:

Iron ore mined in Alabama, 1915-1916, by varieties, with percentage of increase in 1916 in long tons.

YEAR	Hematite	Brown ore	Total Quantity	Percentage of total U. S. Produc'n.
1915	4,374,309	935,045	5,309,354	9.74
1916	5,672,005	1,075,896	6,747,901	8.99
Increase	1,297,696	140,851	1,438,547	.....
Percentage	29.44	15.06	27.09	.....

Iron ore shipped from Alabama mines, 1915-1916.

YEAR	Quantity (Gross tons)	Value
1915	5,134,955	$6,798,266
1916	6,801,839	10,843,231
Increase	1,666,884	4,044,965
Percentage	32	59

Average price per gross ton of iron ore shipped from mines in Alabama and the United States, 1915-1916.

	HEMATITE		BROWN ORE	
	1915	1916	1915	1916
Alabama	$1.25	$1.52	$1.68	$1.97
United States	1.80	2.32	1.80	2.03

General Average, 1915—$1.83; 1916—$2.34.

Rank of the first five states in mined and marketed production of iron ore in 1915 and 1916.

1915

Rank	STATE	MINED		MARKETED			
		Quantity (long tons)	Percentage of total product'n	Quantity (long tons)	Percentage of total product'n	Value	Percentage of total value
1	Minnesota	33,464,660	60.27	32,545,236	58.63	$57,742,643	57.01
2	Michigan	12,514,516	22.54	13,664,437	24.63	28,218,627	27.86
3	Alabama	5,309,354	9.74	5,134,955	9.76	6,798,266	6.71
4	Wisconsin	1,095,388	1.97	1,125,269	2.03	2,188,012	2.16
5	New York	998,845	1.79	931,745	1.68	2,797,270	2.76

1916

1	Minnesota	44,585,422	59.31	45,869,251	58.91	$106,628,784	58.62
2	Michigan	18,071,016	24.04	18,995,797	24.27	49,054,340	26.97
3	Alabama	6,747,901	8.99	6,801,839	8.61	10,843,231	5.96
4	New York	1,342,507	1.78	1,464,917	1.88	5,571,429	3.06
5	Wisconsin	1,304,518	1.72	1,529,459	1.96	3,644,542	2.00

Principal Iron Ore Mines.

In 1916 there were 405 iron ore mines active in the United States, and 222 mines in 1916 produced more than 50,000 gross tons of iron ore each, compared with 184 mines in 1915. Of these 222 mines, 12 produced more than 1,000,000 tons of iron ore each in 1915, 5 more than in 1915. First place in 1916 was held by the Hull-Rust mine at Hibbing, Minn.; second place by Red Mountain group near Bessemer, Ala. The production of the Alabama mines producing more than 50,000 gross tons each in 1916 is given below in tabular form.

Iron ore mines of Alabama that produced more than 50,000 long tons each in 1916.

Rank.	Name of Mine	Nearest Town	Variety of Ore	Quantity
1	Red Mountain Group	Bessemer	Hematite	2,899,588
2	Woodward, Nos. 1, 2 & 3	Lipscomb	Hematite	833,308
3	Songo	Songo	Hematite	248,953
4	Raimund No. 1	Bessemer	Hematite	241,564
5	Steinman	Steinman	Hematite	172,800
6	Greeley	Greeley	Brown Ore	151,927
7	Spaulding	Birmingham	Hematite	134,289
8	Attalla	Attalla	Hematite	117,456
9	Ironaton	Ironaton	Brown Ore	111,416
10	Raimund, No. 2	Bessemer	Hematite	86,965
11	Houston	Rickey	Brown Ore	79,307
12	Docray	Docray	Brown Ore	71,996
13	Raimund, No. 3	Bessemer	Hematite	68,295
14	Tannehill	Goethite	Brown Ore	65,997
15	Valley View, No. 2	Birmingham	Hematite	51,446

Beneficiated Iron Ore.

Statistics of beneficiated iron ore were gathered by the Survey for the first time during the canvass for the year 1914 and, although complete returns were not at first received from every producer who subjects his ore to any form of beneficiation, the responses to the special inquiries have been, on the whole, satisfactory and interesting, and they showed continued improvement in 1915 and 1916.

The following processes were reported as employed to improve the quality of the ore at various mines: Crushing and screening, drying by direct heat and by steam, hand picking on tables and on belts, washing by means of hydraulic jets and logs, jigging, electromagnetic cobbing, other concentration and separation, calcining, nodulizing, and desulphurization by sintering. Some of the operations combined two or more of these processes. Iron ores were reported as beneficiated at 83 mines in 14 States in 1916 and at 66 mines in 14 States in 1915, and in addition at the brown-ore mines of the Spanish-American Iron Co. in Cuba.

In Alabama the ore treated was red hematite and brown ore, and the usual processes to which it was subjected were log washing, screening, and picking belt. A total of 996,344 gross tons of beneficiated brown ore, valued at $1,969,706, was marketed from 12 mines in Alabama in 1916, compared with 744,193 tons, valued at $1,278,344, from 9 mines in 1915. Of this, 117,456 tons were hematite run over a picking belt. (E. F. B.)

PIG IRON.

Production, Shipments, and Value of Pig Iron, By States.

THE bureau of statistics of the American Iron & Steel Institute reports the production in 1916 of all kinds of pig iron, including such ferroalloys as spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus, produced in blast furnaces as well as some that were electrically produced as 39,434,797 gross tons, compared with 29,916,213 tons produced in 1915, an increase of 9,518,584 tons, or 32 per cent.

The following table gives the total production of pig iron in 1915 and 1916, by States, according to their rank each year:

*Pig iron, including some ferroalloys, manufactured in the United States in 1915 and 1916, in gross tons.**

STATE	1915	1916
Pennsylvania	12,790,668	16,506,284
Ohio	6,912,962	8,602,895
Illinois	2,447,220	3,922,512
New York	2,104,780	2,352,535
New Jersey	2,049,453	2,762,885
Alabama	1,986,778	2,221,708
Indiana		
Michigan		
Wisconsin	372,966	811,325
Minnesota		
West Virginia	291,040	554,590
Kentucky		
Missouri	271,921	437,633
Iowa†		
Colorado		
Washington		
California		
Maryland	251,548	501,452
Virginia	251,346	399,885
Tennessee	177,729	355,374
Connecticut	7,802	5,719
Massachusestts		
	29,916,213	39,434,797

*Bureau of Statistics of the American Iron & Steel Institute.
†Ferrosilicon produced in electric furnace for first time in 1916.

Pig iron shipped from blast furnaces in the United States in 1915 and 1916.

STATE	1915		1916		Increase in 1916		Percentage of increase in 1916.	
	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity	Value
Alabama	2,320,255	$23,757,124	2,672,498	$38,994,660	352,243	$15,237,536	15	64
Illinois	2,455,894	34,207,901	3,857,391	67,764,309	1,401,497	33,556,408	57	98
Kentucky	105,700	1,420,275	144,444	2,595,600	38,744	1,175,325	37	83
Michigan	486,106	6,624,559	505,646	8,851,361	19,540	2,226,802	4	34
New York	2,010,076	28,178,466	2,289,608	40,537,240	279,532	12,358,774	14	44
Ohio	6,995,000	90,549,626	8,689,030	136,855,228	1,694,030	46,305,602	24	51
Pennsylvania	12,779,974	174,926,891	16,351,131	293,437,782	3,571,157	118,510,891	28	68
Tennessee	208,298	2,519,337	329,342	4,981,538	121,044	2,462,201	58	98
Virginia	265,616	3,408,784	444,491	7,140,002	178,875	3,731,218	67	109
Wisconsin	302,913	3,997,940	423,973	7,534,327	121,060	3,536,387	40	88
Other States‡	2,454,654	31,818,701	3,418,770	54,786,071	964,116	22,967,370	39	72
	30,384,486	401,409,604	39,126,324	663,478,118	8,741,838	262,068,514	29	65

‡1915; Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

Average Prices.

The average price per gross ton of all kinds of pig iron, by States, from 1911 to 1916, given in the following table is based on reports of the manufacturers to the Survey. These figures represent the prices at the blast furnaces and do not include the prices of ferroalloys.

The average prices for 1915 and 1916 appear low for such active years in the iron industry. Prices, however, did not revive as rapidly as production, and in the early months of the year orders were taken at low prices for delivery late in the year by many producers who did not clearly foresee the future possibilities. At the close of 1915 market prices of pig iron were 35 to 40 per cent above the average for that year and at

the close of 1916 they were between 45 and 68 per cent higher than at the beginning of the year, but this increase was confined almost entirely to the last two or three months of the year, so that the average increase in price was only 28 per cent.

Average price per gross ton of pig iron in the United States, 1911 to 1916.

STATE	1911	1912	1913	1914	1915	1916
Alabama	$10.75	$10.75	$12.08	$10.52	$10.24	$14.59
Illinois	15.30	15.26	15.83	13.59	13.93	17.57
Kentucky	15.01	15.74	16.09	12.24	13.44	17.97
Michigan	15.34	14.30	14.69	13.78	13.63	17.51
New York	15.56	14.22	15.35	14.26	14.02	17.70
Ohio	13.68	13.07	15.02	13.46	12.96	15.75
Pennsylvania	14.23	14.60	15.36	13.78	13.69	17.95
Tennessee	11.56	12.29	13.22	12.05	12.09	15.13
Virginia	12.62	13.27	13.96	12.53	12.83	16.06
Wisconsin	15.51	14.33	15.13	13.35	13.20	17.77
Other States*	14.94	14.07	15.50	13.55	12.96	16.03
Average for United States	14.07	13.93	15.08	13.42	13.21	16.96

1911: California, Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1912 and 1913: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey and West Virginia; 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

Blast Furnaces.

The number of furnaces in blast on June 30 and December 31 and the total number of stacks recorded for the years 1915 and 1916, not including any electric reduction furnaces, as published by the bureau of statistics of the American Iron and Steel Institute, are as follows:

Blast furnaces in the United States, 1915 and 1916.

STATE	Furnaces in blast June 30, 1915.	Dec. 31, 1915			Furnaces in blast June 30, 1916	Dec. 31, 1916		
		In.	Out.	Total.		In.	Out.	Total.
Pennsylvania	96	125	31	156	132	127	30	157
Ohio	50	62	12	74	67	65	12	77
Illinois	12	21	5	26	23	24	0	24
Alabama	20	27	20	47	31	29	18	47
New York	16	18	9	27	20	18	9	27
Virginia	5	7	15	22	9	9	13	22
Tennessee	5	6	12	18	12	11	7	18
Colorado	2	2	4	6	4	3	3	6
Iowa	.....	.....	.....	.....	0	0	0	0
Missouri	1	1	1	2	1	2	0	2
Oregon	0	0	1	1	0	0	1	1
Washington	.....	.....	.....	.....	.....	.....	.....	.....
California	0	0	0	0	0	0	0	0
Maryland	2	3	2	5	4	4	1	5
New Jersey	1	1	4	5	1	1	4	5
Wisconsin	4	7	1	8	6	5	3	8
Minnesota	1	2	0	2	3	3	0	3
Indiana	10	10	0	10	10	10	0	10
Michigan	8	11	3	14	12	12	2	14
West Virginia	1	3	1	4	4	4	0	4
Kentucky	1	3	3	6	4	4	2	6
Georgia	0	0	4	4	0	0	4	4
Texas	0	0	2	2	0	0	2	2
Mississippi	0	0	1	1	0	0	1	1
Connecticut	1	1	2	3	0	1	2	3
Massachusetts	0	0	2	2	1	1	1	2
	236	310	135	445	344	333	115	448

Of the ferro-alloys used in the manufacture of steel only the ferro-manganese and spiegeleisen are manufactured in Alabama at two localities. In 1916 ferro-manganese was valued at $134.42 a long ton, and spiegeleisen at $33.68 a ton as against $64.14 and $20.98 a ton respectively for 1915. This great increase in value stimulated the search for deposits of manganese in the State, but production in very limited quantity by one company only has been reported for 1916 in the State.

Steel.

The figures for the production of steel in Alabama in 1916 are not available for publication.

LIME.

DURING the year 1916 there was an increase in the production of lime in Alabama, as compared with the production of the preceding year. The total product of 9 plants in 1916 was 67,524 short tons, an increase from 1915 of 7,192 tons, or 11.92 per cent.

The value of the product was $312,531, an increase of $62,304 or 24.89 per cent.

The most important use of the lime produced was for building purposes, 11.32 per cent of the product is definitely so credited in the returns while the greater part of the lime sold to dealers and most of the hydrated lime go to building purposes. Other chief uses of lime are in chemical works, paper mills, tanneries, agriculture, manufactories of sand-lime brick, slag cement, etc.

Shelby County, as heretofore, was the largest producer in 1916, being credited with 52,809 tons or 78.21 per cent of the total. The other producing counties in the order of their importance are Blount and Jackson.

The following tables give some additional data on the lime production in Alabama in 1915 and 1916.

For a full account of the lime industry in the United States, those interested are referred to the article on Lime, by G. F. Loughlin, in "Mineral Resources of the United States, 1916."

Lime burned and sold in Alabama in 1915 and 1916.

YEAR	Rank of state by quantity	Quantity (short tons)	Value	Rank of state by value	Average price per ton	Number of plants in operation
1915	16	60,332	$250,227	17	$4.15	14
1916	16	67,524	312,531	23	4.63	9
Increase	.....	7,192	62,304	.....	.....	.....
Percentage	.....	11.92	24.89	.....	.....	.....

Lime sold in Alabama in 1915 and 1916, by uses.

	Quantity (short tons)	Value	Average price per ton U. S.
1915			
Building lime	13,177	$54,976	*$4.26
Chemical works	1,369	5,769	3.36
Paper mills	†	†	3.61
Sugar factories	801	3,368	6.77
Tanneries	†	†	4.06
Agriculture	379	1,308	*3.21
Dealers, uses not specified	40,031	169,600	4.22
Other uses and undistributed	4,575	15,206	.....
Total	60,332	$250,227	.....
Hydrated lime (included in total)	6,302	28,553	.....
1916			
Building lime	7,744	$33,069	$5.21
Chemical works	703	2,571	3.70
Paper mills	†	†	4.14
Sugar factories	.....	.....	5.41
Tanneries	†	†	4.64
Agriculture	592	2,246	3.63
Dealers, uses not specified	50,007	243,582	4.95
Other uses, and undistributed	8,478	31,063	.....
Total	67,524	$312,531	.....
Percentage of increase in 1916	11.92	24.89	.....
Hydrated lime (included in total)	6,780	36,864	.....
Percentage of increase in hydrated lime in 1916	7.58	29.11	.....

*Revised. †Included in "Other uses and undistributed."

MANGANESE.

THERE has been very little production of manganese during the past few years. Only one company has reported production in 1916 from near Walnut Grove in Etowah County. A second firm has reported some progress in development. Because of the great demand for manganese in the time of

the war, thorough investigation should be made of some of the most promising localities. Among these localities worthy of further investigation are Murphree's Valley in Blount and Etowah, Shinbone Valley in Clay County, and many other localities in Etowah, St. Clair, Calhoun and Cleburne counties mentioned in the State Geological reports. In the Shinbone Valley along the eastern foot hills of the Talladega Mountain range, there is a practically continuous outcrop of manganese ore which can be followed up to the southern boundary of Cleburne County.

Many specimens of high-grade merchantable ore have been collected from these outcrops, but the prospecting has not yet shown that the quantity of such high-grade ore will justify the working on commercial scale.

MICA.

MICA mines were opened in Alabama during the early days of mica mining in the Southern States. Prospects have been tested at various subsequent times, and considerable mining has been carried on at intervals during the last twenty years.

The mines are located in Randolph, Cleburne, Clay and Tallapoosa counties, and there are prospects also in Lee, Coosa, and Chilton counties.

In 1916 there were six mines producing mica as against four in 1915. The output was 14,132 pounds of sheet mica, valued at $4,955, and a few hundred dollars worth of scrap mica.

The output of sheet mica in 1915 was 8,400 pounds valued at $5,545, showing an increase in 1916 of 5,732 pounds or 68.24 per cent, but a decrease in the value of $590.00 or over 10 per cent.

MINERAL WATERS.

By Arthur J. Ellis.

Character of Statistics.

THE statistics given in this report have been compiled from individual reports furnished by the owners or operators of springs and include, so far as can be ascertained, only natural waters that are bottled and sold in their natural state or only slightly altered from their natural state. Natural still waters that have been artificially carbonated, natural carbonated waters that have lost part of their carbon dioxide, and waters from which iron has been removed are included; but artificial waters and natural waters that have been flavored, concentrated, fortified, diluted, or otherwise essentially modified in chemical character are excluded if available information indicates such treatment. Water given away or consumed at spring resorts, which constitutes a large part of the annual production, is excluded. Waters sold at flat or meter rates, delivered to consumers through pipes, or otherwise obviously municipal supplies or adjuncts to them are excluded. This is the nearest practicable conformity with the commonly accepted definition of natural mineral water. No distinction is made between mineral water flowing or pumped from a natural spring and that flowing or pumped from a dug, bored, driven, or drilled well. Many of the best-known mineral waters in the United States come not from natural springs but from wells.

Distinction for statistical purposes between table and medicinal waters is entirely arbitrary. Most table waters are clear, sparkling, and without distinct mineral taste or odor; many medicinal waters are highly mineralized and have distinct mineral taste and odor. Yet some table waters are more strongly mineralized than some medicinal waters, and many medicinal waters contain less mineral matter than certain city supplies. The basis here used for distinguishing medicinal from table waters is the report regarding the spring, and this distinction is based in turn on the operator's knowledge that some of his customers buy the water to use regularly on their

tables and others buy it for an aid during illness. A few strongly mineralized waters are not sold as table waters, and a few widely sold table waters are not used medicinally, but many waters are sold for both uses, though the reported sales of several medicinal waters have distinctly decreased in the last few years.

Mineral Water Trade in Alabama, 1916.

Returns from Alabama indicate that the mineral-water trade in 1916 was about 20 per cent more than that in 1915. The sales amounted to 103,944 gallons, and the value of the output was $12,174, the average price per gallon increasing from 10 cents to 12 cents. There was a considerable decrease in the value of the output of medicinal waters, but the large increase in the sales of table waters netted a gain of $3,262 in the total sales. Sixteen springs reported sales. One spring which was active in 1915 reported no sales for 1916. Gordon Mineral Springs is newly added to the list. Seven mineral-water bathing establishments and 5 resorts, accommodating about 800 guests, were maintained. The quantity of mineral water used in the manufacture of soft drinks increased from 2,300 gallons to 13,500 gallons.

The following 16 springs reported sales:

Bailey Springs, Florence, Lauderdale County.
Bladon Springs, Bladon Springs Choctaw County.
Blount Springs, Blount Springs, Choctaw County.
Bromberg Gulf Coast Lithia Spring, Bayou Labatre, Mobile County.
Cooks Springs, Cooks Springs, St. Clair County.
Dixie Spring, Dixie Spring, Walker County.
Gordon Mineral Springs, Canoe, Escambia County.
Healing Springs, Healing Springs, Washington County.
Livington Mineral Well, Livingston, Sumter County.
Luverne Mineral Spring, Luverne, Crenshaw County.
McCary Mineral Well, near Birmingham, Jefferson County.
Matchless Mineral Water Well, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
Shocco Springs, Talladega, Talladega County.
Talladega Springs, Talladega Springs, Talladega County.
White Sulphur Wells, near Jackson, Clarke County.

The following tables add some details to the general statements above given:

Mineral waters sold in Alabama in 1915 and 1916.

YEAR	Commercial Springs	Quantity Sold (gallons)	Average price per gallon (cents)	Value of medicinal waters	Value of table waters	Total value
1915	14	86,499	10	$8,213	$699	$8,912
1916	16	103,944	12	5,979	6,195	12,174

Comparative production of mineral waters in Alabama in 1915 and 1916.

YEAR	Commercial Springs	Quantity sold (gallons)	Value of product
1915	14	86,499	$8,912
1916	16	103,944	12,174
Increase	2	17,445	3,262
Percentage of increase		20	37

A comparison of American and European Mineral waters, by Alfred A. Chambers, is given in "Mineral Resources of the United States, Part II, pages 500-508." A discussion of the waters of Alabama, may be found in a report of the Geological Survey of Alabama, "Underground Waters of Alabama," by Eugene A. Smith, State Geologist, 1907.

NATURAL GAS.

By JOHN D. NORTHROP.

IN 1916 natural gas in sufficient volume to supply the needs of 250 domestic consumers in Fayette, was obtained from four wells, one of which was completed during the year in the Fayette Gas Field, Fayette County, and enough for the needs of 85 domestic consumers in the town of Jasper, was obtained from two wells in Walker County.

Wild cat tests drilled in 1916 in quest of petroleum near Mobile, Mobile County, in southern Alabama, resulted in the discovery of numerous pockets of natural gas, but no commercial production of gas.

Nine wells in Madison County and one in Winston County in northern Alabama were reported closed in 1916.

Some details concerning the oil and gas situation in Alabama may be found in Bulletin 10 of the Geological Survey, Report on the Fayette Gas Field by M. J. Munn, and in Circular No. 3 Concerning Oil and Gas in Alabama, by Eugene A. Smith.

PETROLEUM.

By JOHN D. NORTHROP.

NOTHING of consequence resulted from the quest for petroleum in Alabama in 1916. Late in December the discovery of oil in small quantities near Cordova, Walker County, furnished the basis for considerable local excitement, which, however, failed to result in the opening of a new field. So-called blow-outs near Mobile provided an incentive for drilling in that locality, and at the end of 1916 tests were under way west of that city.

SAND AND GRAVEL.

THE total production of sand and gravel in the State in 1916 was 726,650 short tons, valued at $184,216, as compared with 924,701 tons, valued at $242,336 in 1915, a decrease in the quantity of 198,051 tons, or 21.42 per cent, and a decrease in the value of $58,120, or 23.99 per cent.

There was an increase in the quantity of sand of 250,532 short tons, or 66.44 per cent, and in the value of $22,288, or 17.73 per cent. There was a great falling off in the quantity

and value of the gravel, viz., a decrease of 448,583 tons, or 81.91 per cent in quantity, and of $80,408, or 68.91 per cent in value.

Railroad ballast, building and molding sands make 91.61 per cent of the sand production; railroad ballast 41.58, building 35.11 and molding sand 20.92 per cent, while the balance of 2.39 per cent represents the production of grinding and polishing, paving and other unclassified sands.

The following tables give a comparison of the production of sand and gravel in 1915 and 1916, and the production, value and kinds of sands in these two years.

Production in short tons of sand and gravel in Alabama in 1915 and 1916.

	SAND		GRAVEL		Total*		Percentage of U. S. total
	Quantity	Value	Quantity	Value	Quantity	Value	
1915	377,045	$125,664	547,656	$116,672	924,701	$242,336	1.05
1916	627,577	147,952	99,073	36,264	726,650	184,216	0.62
Increase or decrease	+250,532	+22,288	—448,583	—80,408	—198,051	—58,120	0.62
Percentage	+ 66.44	+ 17.73	— 81.91	— 68.91	— 21.42	— 23.99	.....

*Chert has been added to these totals.

Quantity (short tons), value and kind of sand produced in Alabama in 1915 and 1916.

	Moulding Sand		Building Sand		Paving Sand		Engine Sand		Grinding and Polishing Sand		Railroad Ballast Sand and Gravel		Other Sands		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1915	169,663	$59,862	157,581	$51,788	*	*	6,942	$1,779	*	*	*	*	7,294	$2,180	377,045	$125,664
1916	131,312	41,470	220,336	66,989	*	*	6,199	1,741	*	*	259,957	$32,413	*	*	627,577	147,952
Increase+ or Decrease—	—38,351	—18,392	*62,755	*15,201	.....	.....	— 743	— 38	.....	.....	.....	.....	.....	.....	+250,532	+22,288
Percentage	— 22.60	— 30.72	+ 39.82	+ 29.35	.....	.....	—10.70	—2.14	.....	.....	.....	.....	.....	.....	+ 66.44	+ 17.74

*Concealed because of less than three producers.

STONE.

EUGENE A. SMITH.

ON ACCOUNT of the variety of uses to which stone is put, there is no regular unit of measurement, and the figures in this report represent the values of the different varieties.

PRODUCTION.

Alabama produces only three kinds of stone, viz., limestone, marble and sandstone.

The total value of the stone produced in Alabama shows an increase in 1916 of 67.17 per cent. The greater part of this increase was in the limestone, (rough and dressed building stone, and furnace flux). There was a notable decrease in the sandstone, while the production of marble was practically the same as in 1915. Exact figures for marble, however, cannot be given as there were in 1915 as well as in 1916 only two producers.

The following table gives some additional details of the total stone production:

Total value of stone (limestone, sandstone and marble) produced in Alabama in 1915 and 1916. Percentage of total U. S. value, rank of State and number of plants.

Year	Total Value	Percentage of total U. S. value	Number of Plants	Rank of State
1915	$719,452	.96	25	28
1916	1,202,256	1.52	25	20
Increase in 1916	482,804			
Percentage	67.17			

LIMESTONE.

The most important use of limestone produced in Alabama in 1916 as in 1915, was for furnace flux, while building stone, both rough and dressed, follows next in importance. For the other uses given in the table the value of the limestone shows

a decrease, notably in the case of the stone used in road-making.

The limestone burned into lime or used in the manufacture of Portland cement is not taken into account here, but is included in the value of each of the finished products in whose manufacture it was used.

As thus limited the total value of the limestone produced in 1916, was $917,559, as compared with $426,266 in 1915, an increase of $491,293 or 115.26 per cent.

The value of the limestone produced in Alabama in 1915 and 1916 classified according to the uses of the stone is given in the following table:

Value of limestone (not including marble) produced in Alabama in 1915 and 1916, according to uses.

USES	1915	1916	Increase or Decrease	Percentage
Rough building	$6,912	$13,067	+ $6,155	+ 89.19
Dressed building	15,487	29,597	+ 14,110	+ 91.11
Riprap	18,379	17,969	— 410	— 2.23
Crushed Stone:				
Road making	42,116	1,198	— 40,918	— 97.15
Railroad ballast	554	180	— 374	— 67.51
Concrete	45,443	41,321	— 4,122	— 9.03
Flux	289,167	807,344	+ 518,177	+ 179.19
Agricultural	7,386	4,656	— 2,730	— 36.96
Other	822	2,227	.....	.....
Total	$426,266	$917,559	+ 491,293	+ 115.26

Limestone For Building Purposes.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood in Franklin County, operated by Foster and Creighton Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the

University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which cannot be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses a quality of cheapness, it can be cut to any design required, and is at the same time strong and durable.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

The above statements are confirmed by a report on the comparative tests made on the Rockwood stone, and those from Bedford, Ind., and Bowling Green, Ky., by Prof. Robert H. McNeilly, in the Engineering Laboratory of Vanderbilt University.

From this report I give the following extracts:

"GENERAL CHARACTERISTICS.—The Rockwood limestone is an almost pure oolitic limestone with frequent small crystals of calcite distributed throughout its mass. It resembles closely

Graphite Development Co., the Hood Graves Co., the Norway Graphite Co. (property in sec. 22, T. 20 S., R. 6 E.), and the Superior Flake Graphite Co. (property in secs. 15, 21, and 22, T. 19 S., R. 8 E.).

Coosa County.

The graphite-bearing belt of Coosa County extends from Goodwater southwestward to Coosa River. It is only in the Goodwater region, however, that active work is in progress. No production was made from this district during 1916, but in April, 1917, one company had a mill in full operation, another was building its mill, and three more contemplated beginning construction within a short time.

The Ceylon Co. (office, Birmingham, Ala.) has erected a large mill in the NE. ¼ sec. 16, T. 24 W., R. 19 E. A special process is used, the details of which are not made public. The graphite-bearing schist is said to average about 150 feet in width and has been prospected for 1,000 feet along the strike. The strike is about N. 35° E. and the dip is 55°-60° SE. The outcrop follows the crest of a prominent ridge, on the north side of which the mill has been built. An open cut is being carried across the deposit to the level of the ore bin, and it is planned to work back from this toward the mill, thus gaining the advantage of working against the dip. The ore grades off on the walls into leaner quartz schist containing small bands of graphitic schist. The graphite is shipped from Hollins, a station on the Central of Georgia Railway about 7 miles west of Goodwater.

The Goodwater Graphite Co. (office, Goodwater, Ala.) is erecting a mill about 1½ miles northwest of Goodwater and expects to be ready for operation by June 1, 1917. The ore will be crushed by a series of jaw crushers and rolls and circular water-flotation machines will be used for concentration. The graphite-bearing schist, which has a width of about 40 feet, strikes N. 70° E. and dips about 25° SE.

The Graphite Co. of America (office, Birmingham, Ala.) is planning to develop a large area of about 2 miles northwest of Goodwater, between the property of the Goodwater Graphite Co. and the Hatchet Creek. Graphite-bearing schist has been exposed in several pits and trenches. The strike is about N. 70°

E. and the dip averages 45° SE. It is planned to use a dry process in the mill.

The Royal Graphite Co. and the United Graphite Co. are also prospecting lands in the vicinity of Goodwater.

Chilton County.

The only plant in operation in Chilton County is the Flaketown Graphite Co., about 3½ miles northeast of Mountain Creek station on the Louisville & Nashville Railroad. The property was visited by Mr. Bastin in May, 1916, and will be described at length in the forthcoming bulletin on graphite deposits of the United States. A special process is employed at the mill, the details of which are not made public.

FUTURE OF THE ALABAMA GRAPHITE INDUSTRY.

The large number of new companies beginning operations at the present time naturally makes it of importance to consider the probable effect of the future increased production upon the market. If all the mills in the Alabama field are able to operate at anything like their expected capacity, the result will be an annual production of flake graphite of approximately 30,000,000 pounds, about 15 times the production of Alabama in 1913, and nearly equal to the entire importation from Ceylon for that year. As long as the war continues a largely increased production can probably be absorbed by crucible makers and other users of crystalline graphite, but if the graphite from Ceylon and Madagascar continues to enter the market freely, the price of domestic graphite will necessarily be reduced with the increase in production. On the other hand, mining conditions in Alabama are very favorable, the mining costs are low, and new developments in concentration and finishing will probably result in a larger percentage of good flake in the finished product and a higher saving of graphite of all grades. Costs of mining and milling at an efficiently managed plant should not exceed $50 a ton of concentrates produced, or about 2½ cents a pound for the finished product, and even with prices as low as 5 cents a pound for No. 1 flake, 3 cents for No. 2, and 1½ cents for dust, there should still be a possibility of profit. A recent article by Prouty* contains an interesting dis-

*Prouty, W. F., Extent and development of flake graphite resources of Alabama; Manufacturers' Rec., Apr. 19, 1917, pp. 66-67.

cussion of costs of production of graphite in Alabama. It is of course idle to speculate on the possible duration of present conditions, and the situation may be summed up by saying that as long as the present demand for crucibles in the manufacture of munitions continues, the plants in operation should all be able to make profits, and even with the expected drop in prices after the war the most favorably situated and efficiently managed plants should continue to be profitable.

With a return of peace, however, operators will face an unfavorable condition caused by a decreased market and large increase in production.

IRON ORE.

ERNEST F. BURCHARD.

EUGENE A. SMITH.

ESSENTIAL FEATURES OF AN IRON-ORE DEPOSIT.

THE war in Europe has greatly stimulated prospecting for minerals and ores in the United States, and as a result of this prospecting many specimens are sent to the United States Geological Survey for identification. The majority of specimens are readily identified at sight; some require a brief visual examination; others require more elaborate physical or chemical tests. The Survey is not permitted to make chemical analyses or assays of minerals or ores for private persons or corporations, but it is compatible with the duties of the Survey to inspect a specimen and to state, if possible, what it is; to give an offhand opinion as to whether or not the material constitutes an ore; and to recommend or discourage further expense in prospecting it or in having analyses or assays made.

Iron minerals are among the most common and are abundantly distributed, and naturally many specimens are received by the Geological Survey. It is therefore believed that a few notes on these minerals and on the requirements of a deposit in order to render it of commercial importance may be of interest to those making inquiries on the subject. The classes

of iron minerals that constitute a source of iron ore are oxides and carbonates. There are three general varieties of oxides, viz, hematite, brown ore, and magnetite. Brief descriptions of each follow.

SOURCE OF IRON.

The forms in which iron occurs in the earth in combination with other substances are very numerous. Nearly all hard rocks, as well as the softer soils, sands, clays, and many "mineral" waters contain iron in some combination and in varied proportions. Iron is seldom found "native"—that is, occurring in the earth in the form of metallic iron. When it is found in the metallic state, as, for instance, in meteorites that have fallen from space upon the earth, it is not in quantities large enough to be of commercial value. The combination of iron with one or more other substances is called an iron compound, or iron mineral, and where the iron compounds are such that iron can easily be extracted from them and they occur in such abundance that they can be mined profitably these iron compounds are called iron ores.

Iron in combination with other substances is regarded next to aluminum, a metal contained in clay, as the most abundant metal. Thus, according to recent calculations,* metallic iron forms about 4.50 per cent of the rock crust of the earth, compared with 7.85 per cent for aluminum.

IRON ORE.

There are four important types of ores of iron—red iron ore, or hematite; brown ore, or limonite; magnetic ore, or magnetite; and carbonate ore, or siderite—although there are hundreds of minerals in which iron is a constituent. These types of ore may easily be remembered through their most common colors, which are, respectively, red, brown, black and grayish.

Hematite.

Hematite includes all varieties of the anhydrous sesquioxide (Fe_2O_3). This is known locally as red hematite, specular ore,

*Clarke, F. W., The data of geochemistry, 3d ed.; U. S. Geol. Survey Bull. 616, p. 34, 1916.

gray ore, fossil ore, oolitic ore, etc. Hematite is composed of two parts of the metal iron united with three parts of oxygen. Iron forms 70 per cent by weight of pure hematite and oxygen 30 per cent, and the mineral is known chemically as the sexquioxide of iron or ferric oxide. Hematite may occur as a rock in beds, in veins, or in masses of irregular shape, and it may occur in a soft, earthy state, or as a loose debris in the soil, and yet in all these forms be profitably mined if the controlling conditions are favorable. Hematite is easily recognized in the hand specimen by its colors (red to steel-gray and black) and the red mark or streak it leaves when drawn across a rough surface and by its high specific gravity or superior weight as compared with the weight of pieces of ordinary red rock or red clay of equal size. The old-fashioned "keel" or red chalkstone formerly used by carpenters for marking lumber is a form of hematite. Finely ground hematite is used in the manufacture of red paint and other red coloring materials.

Hematite is by far the most important iron ore. It is found in great abundance in the United States in the vicinity of Lake Superior in Minnesota, Michigan, and Wisconsin; in central New York; in the Appalachian region of Alabama, Georgia, Tennessee, and Virginia; and in eastern Wyoming. It also occurs in lesser quantities in Pennsylvania, Maryland, Kentucky, eastern Wisconsin, Utah, and California. (E. F. B.)

All the ore of this quality mined in Alabama occurs in the Clinton or Red Mountain formation. The Red Mountain ridges occur on each side of the anticlinal valleys which separate the coal fields. In places the red ore ridges are lacking on one side, usually the western, of the valleys, being cut out by faults, while on the other hand the ridge may be duplicated on one side of the valley by the same faults.

In most of the valley occurrences the moderate dips of the ore bed are on the eastern side and there are also practically all of the ore mines. Murphree's Valley makes an exception to this, the moderate dips and the iron mines being on the western side. The iron ore occurs mainly in the central part of the formation in seams or beds one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop which in Alabama must be as much as 50 miles, yet they vary

greatly from place to place, being either too thin or too lean for profitable working in the greater part of this distance.

The most important development of the Clinton ore in this State and in the world is along the 15 or 16 miles stretch of the east Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines and strippings for this entire distance. Much mining of this ore has also been done near Gate City, Village Springs, Attalla, Gadsden, Round Mountain, Gaylesville, Fort Payne, Valley Head, etc.

The completion in October, 1912, of a diamond drill boring in Shades Valley, within a mile of the base of Shades Mountain, gives a definite answer to the speculations concerning the occurrence of red ore under Shades Valley. This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop on Red Mountain is not too great for shaft mining.

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be overestimated.

In 1913 the Gulf States Steel Company acquired about 1,500 acres of land upon which the drill hole above mentioned was located. They have since sunk a double track slope to the ore. In time this is likely to be the largest producing mine in the State.

Another drill hole was put down in Shades Valley in 1913, in Section 19, T. 19, R. 3 W., but the record was not available for publication at the present time.

The hematite production in Alabama in 1916 was 5,672,005 long tons, as against 4,374,309 tons in 1915, an increase of 1,297,696 tons or 29.44 per cent. This 1916 production of hematite is 84.05 per cent of the total iron ore production of the State, and 7.55 per cent of the total iron ore production of the United States.

The average price of hematite in Alabama in 1915 was $1.25; in 1916, $1.52. (E. A. S.)

Brown Ore.

Brown ore is composed of iron, oxygen, and water, and in a general way might be said to be hematite combined with water. A general formula may be expressed by $nFe_2O_3nH_2O$. Brown ore may contain water in several proportions so that the percentage of iron likewise varies, but the latter ranges generally from 52 to 66 per cent in the pure mineral. Thus brown ore does not contain quite as high a percentage of iron as hematite, and therefore it can not yield so much metal. One of the most common brown ore minerals is known as limonite ($2Fe_2O_3 3H_2O$), and this contains 59.9 per cent of iron, 25.7 per cent of oxygen, and14.4 per cent of water. Brown ore occurs in a large variety of forms, nearly all of which have in common a characteristically yellowish-brown to chocolate-brown color and yield a brown streak and powder. Exceptionally certain hydrated sesquioxides of iron may appear bright red, and some may show black surfaces; but these exceptional forms are generally to be found closely associated with a mass of ordinary brown ore, and familiarity with the deposits soon dispels any perplexity regarding the nature of the ore on the part of persons mining or handling it. The specific gravity of brown ore is also higher than that of ordinary rock. Brown ore commonly occurs in irregular masses and lumps, and as ore gravel and sand, embedded in banks of clay, sand, and stone gravel. The ore in places lies in layers, but more commonly in irregular pockets, separated by barren clay, sand, and stone gravel. In places the ore takes the form of hollow concretions or "pots" which may contain some loose sand or clay in the interior, and also it appears as honeycombed masses ramifying through the inclosing ore-bearing ground.

Limonite is used chiefly as a source of iron, but the brown and yellow forms, called ocher, are used for paint and for making oil-cloth and linoleum. A porous variety of limonite is used in the purification of illuminating gas, and also as a contact material in the production of hydrogen gas for inflation of dirigible balloons and for precipitation of fats from oils. Many iron compounds are used in medicines.

Deposits of brown iron ore are common in many portions of the eastern United States, particularly in valleys underlain by limestone. Some of the best-known deposits are in Con-

necticut, Vermont, Pennsylvania, Virginia, Tennessee, Alabama, northeastern Texas, and in Iowa and Wisconsin near Mississippi River. (E. F. B.)

This ore, the second in importance in the State, and third in the United States, furnishes only 1.43 per cent of the total iron ore production of the United States, and 15.94 per cent of the iron ore production of the State in 1916. The entire brown ore production of the United States in 1916 was 1,904,484 long tons of which Alabama contributed 1,075,896 tons or 56.49 per cent, and the State holds accordingly the first rank in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the State. It was then demonstrated that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in

the different ore banks, but also in the different parts of the same bank.

The deposits occur in nearly all the geological formations of the State, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur overlying the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally occur also in the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The limonite or brown ore production of Alabama in 1916 was 1,075,896 long tons as against 935,045 tons in 1915, an increase of 140,851 tons or 15.06 per cent.

The average price per long ton of brown ore marketed in Alabama in 1916 was $1.97, as against $1.68 in 1915. (E. A. S.)

Magnetite.

Magnetite (Fe_3O_4) is a black ore of iron which is attracted by the magnet. It contains iron and oxygen in the proportion of 3 parts of iron to 4 parts of oxygen, which by weight gives 72.4 per cent of iron and 27.6 per cent of oxygen. Magnetite thus contains the highest percentage of iron of the ores thus far mentioned, and in fact, of all the iron ores. Magnetite usually occurs in granular form and in crystals in veins in comparatively old crystalline rocks, although it may be found in comparatively young volcanic rock.

Magnetite is found in the United States in considerable quantities in the Adirondack region of New York, the Highlands of New Jersey, south Pennsylvania, eastern Wyoming, central Texas, southwestern Utah, and southern and northern California, and in small quantities in northern Michigan and in other States. It is used chiefly for the production if iron, but the less common variety known as lodestone, which is naturally magnetic, is sold at high prices for museum exhibits and for laboratory purposes. Magnetite is found in the form of sand along streams and on the shores of lakes or seas where it has been concentrated by the action of water. In this form

it has not proved of much commercial value as an ore of iron. (E. F. B.)

There has been no development of magnetic ore properly speaking, in Alabama. The gray ore of Talladega county which was mined to some extent a few years ago is essentially a hematite though some of it is slightly magnetic. There was no production of this ore in 1916. (E. A. S.)

Siderite.

Siderite, or iron carbonate ($FeCO_3$), is composed of 1 part of iron, 1 part of carbon, and 3 parts of oxygen and thus contains by weight where pure, approximately 48.3 per cent of iron, 10.3 per cent of carbon, and 41.4 per cent of oxygen. Iron carbonate ore where fresh is generally grayish in color, and occurs in nodules and in layers principally in sedimentary rocks that contain coal and lignite. The carbonate rapidly changes to brown ore on exposure to moist air. Siderite is known locally as spathic iron ore, kidney ore, clay ironstone, and blackband ore. Certain of these names are derived from the appearance of the ore in its different forms. For instance, a bed of carbonate ore that is found on the top of a coal bed in eastern Kentucky is striped with fine black carbonaceous bands.

Iron carbonate, in addition to being found in Kentucky, is common in southeastern Ohio, and occurs to a small extent in Pennsylvania, Alabama, Mississippi, and Texas.

IMPURITIES IN IRON ORE.

Consideration should be given to some of the principal impurities that are found in iron ores, first, in order to appreciate why a deposit of ore never yields the full percentage of iron that the predominant iron mineral contains, and, second, in order to show the relation of the ore to the operation of the blast furnace. Deposits of iron ore are generally so closely associated with the rocks which inclose them that they contain either mixed with the deposit or chemically combined within it some of the other rock-forming minerals. Among the most common of these minerals are silica, or sand; lime and magnesia, derived from limestone and dolomite; alumina, a clay mineral; manganese, a metal resembling iron; and small quan-

tities of sulphur and phosphorus. The presence of varying percentages of these and other minerals tends, of course, to reduce the percentage of metallic iron that the deposit will yield when mined, and they must be removed as far as possible in mining and almost completely in the process of making iron. Therefore, it is of the utmost importance that the average chemical composition of a deposit of iron ore be ascertained before an attempt is made to mine it.

The average composition may be termed the "quality" of the deposit. The quality is determined chiefly by two men, the prospector and the chemist. The prospector digs trenches and pits or drills holes in the ore and takes samples of it. The chemist analyzes these samples of ore in his laboratory, and finds the percentages of metallic iron, silica, lime, alumina, manganese, sulphur, phosphorus, water, etc., contained in average samples of the ore. On the quality of the ore depend the quantity of fluxing stone and fuel that must be used in the blast furnace and the kind of iron that can be produced.

RANGE IN COMPOSITION.

Many chemical analyses of commercial grades of these iron ores indicate a range in composition given in the following table:

Range in chemical composition of commercial grades of iron ore.

	Hematite Per cent	Brown ore Per cent	Magnetite Per cent	Carbonate Per cent
Metallic iron	25-65	35-58	48-70	25-48
Silica	2-35	3-23	0.6-20	1-23
Alumina	0.2-9	1.4-12	0.7-4.5	1-5
Lime	Trace to 27	0-0.6	0.5-4.5	0-7
Manganese	Trace to 5	0.16-5	0.07-1.5	0.1-4.7
Sulphur	Trace to 1.5	Trace to 0.5	Trace to 1.2	0.01-1.8
Phosphorus	0.013-1.23	0.04-1	Trace to 1.75	0.043-0.7
Titanium	0-0.9	.....	0-1.5	0-0.04
Water	0.3-6	8.8-15	0.25-0.5	0-6.5

Under exceptional conditions ores are mined that contain more or less of the common constituents indicated above, but local conditions may determine whether an ore that falls within

the limits shown may be mined. For instance, hematite carrying as little as 2 per cent metallic iron would not be considered of value as an ore unless it contained enough lime to flux the silica and alumina present. Most southern red hematites contain considerable quantities of lime and are therefore workable where a highly siliceous ore carrying no more metallic iron and little lime would not be available under present conditions of metallurgic practice. At present ores averaging less than 25 per cent of metallic iron are not charged into blast furnaces in any considerable quantities, and ores as lean as this can not be used economically unless they carry more than enough lime to flux them and are used in connection with richer ore. In using limestone as a flux it would probably be more desirable to use a stone carrying 15 to 20 per cent of ferric oxide (10.5 to 14 per cent metallic iron) than one containing only 3 to 5 per cent ferric oxide, on account of the higher iron yield of the former. Nevertheless, the more ferruginous limestone would not commercially be classed as an ore; yet a bed carrying 35.5 per cent ferric oxide (25 per cent metallic iron), although in itself not quite rich enough, might be conceded to be an "ore." There are other exceptions to be noted in this table. Some deposits of nontitaniferous magnetite can be so treated by means of crushing and electromagnetic separation that, although they may contain as little as 25 per cent metallic iron, they will yield a high grade concentrate. Such ores may be used to advantage, especially where they can be concentrated along with richer grades. Considerable phosphorus is present in the mineral apatite associated with Adirondack magnetite; and this and silica are largely eliminated by electromagnetic concentration. The possibilities of various methods of concentration or beneficiation must therefore be taken into consideration in appraising an ore, and this involves consideration of the physical as well as the chemical character of the ore. The content of water is a widely variable item. Some ores contain much absorbed water, which can be driven off by drying. Hematite is found in all stages of hydration, and thus may contain water up to the point where it should really be classed as a brown ore. Hydrated ores are thus concentrated by heating to drive off the chemically combined water. Carbonate ores are calcined to drive off both carbon dioxide and water. Some iron oxides

are subjected to a partial reduction and are thus rendered magnetic, and the separation of nonmetallic impurities is thereby greatly facilitated. One brown-ore deposit that averages in the raw state not more than 30 per cent of metallic iron is thus through a complicated process of beneficiation rendered of commercial value. The question of beneficiation is therefore becoming increasingly important; and there must also be taken into consideration the proximity to transportation, and to blast furnaces, to water-power sites for possible electric reduction, as well as the prevailing conditions of the market. The laws of supply and demand that prevail in 1917 make available lower grades of ore than would be considered desirable in times when low prices for iron and steel are current. The question of quantity available is also of importance, for iron ore is so bulky a product, is relatively so low in value even at the best, and involves so large an expenditure for equipment for mining on a satisfactory scale that any deposit should contain several years' supply to be worthy of development.

To summarize, then, the ore should occur in a deposit containing several hundred thousand tons of merchantable grade, susceptible of economical mining and convenient to transportation and markets, if its development is to be seriously considered. (E. F. B.)

Details of Iron Ore Production In Alabama, 1915-1916.

The following tables show details concerning the production of iron ore in the State, together with the rank of the State in mined and marketed iron ore in 1915 and 1916:

Iron ore mined in Alabama, 1915-1916, by varieties, with percentage of increase in 1916 in long tons.

YEAR	Hematite	Brown ore	Total Quantity	Percentage of total U. S. Produc'n.
1915	4,374,309	935,045	5,309,354	9.74
1916	5,672,005	1,075,896	6,747,901	8.99
Increase	1,297,696	140,851	1,438,547	.....
Percentage	29.44	15.06	27.09	.....

Iron ore shipped from Alabama mines, 1915-1916.

YEAR	Quantity (Gross tons)	Value
1915	5,134,955	$6,798,266
1916	6,801,839	10,843,231
Increase	1,666,884	4,044,965
Percentage	32	59

Average price per gross ton of iron ore shipped from mines in Alabama and the United States, 1915-1916.

	HEMATITE		BROWN ORE	
	1915	1916	1915	1916
Alabama	$1.25	$1.52	$1.68	$1.97
United States	1.80	2.32	1.80	2.03

General Average, 1915—$1.83; 1916—$2.34.

Rank of the first five states in mined and marketed production of iron ore in 1915 and 1916.

1915

Rank	STATE	MINED		MARKETED			
		Quantity (long tons)	Percentage of total product'n	Quantity (long tons)	Percentage of total product'n	Value	Percentage of total value
1	Minnesota	33,464,660	60.27	32,545,236	58.63	$57,742,643	57.01
2	Michigan	12,514,516	22.54	13,664,437	24.63	28,218,627	27.86
3	Alabama	5,309,354	9.74	5,134,955	9.76	6,798,266	6.71
4	Wisconsin	1,095,388	1.97	1,125,269	2.03	2,188,012	2.16
5	New York	998,845	1.79	931,745	1.68	2,797,270	2.76

1916

1	Minnesota	44,585,422	59.31	45,869,251	58.91	$106,628,784	58.62
2	Michigan	18,071,016	24.04	18,995,797	24.27	49,054,340	26.97
3	Alabama	6,747,901	8.99	6,801,839	8.61	10,843,231	5.96
4	New York	1,342,507	1.78	1,464,917	1.88	5,571,429	3.06
5	Wisconsin	1,304,518	1.72	1,529,459	1.96	3,644,542	2.00

Principal Iron Ore Mines.

In 1916 there were 405 iron ore mines active in the United States, and 222 mines in 1916 produced more than 50,000 gross tons of iron ore each, compared with 184 mines in 1915. Of these 222 mines, 12 produced more than 1,000,000 tons of iron ore each in 1915, 5 more than in 1915. First place in 1916 was held by the Hull-Rust mine at Hibbing, Minn.; second place by Red Mountain group near Bessemer, Ala. The production of the Alabama mines producing more than 50,000 gross tons each in 1916 is given below in tabular form.

Ion ore mines of Alabama that produced more than 50,000 long tons each in 1916.

Rank.	Name of Mine	Nearest Town	Variety of Ore	Quantity
1	Red Mountain Group	Bessemer	Hematite	2,899,588
2	Woodward, Nos. 1, 2 & 3	Lipscomb	Hematite	833,308
3	Songo	Songo	Hematite	248,953
4	Raimund No. 1	Bessemer	Hematite	241,564
5	Steinman	Steinman	Hematite	172,800
6	Greeley	Greeley	Brown Ore	151,927
7	Spaulding	Birmingham	Hematite	134,289
8	Attalla	Attalla	Hematite	117,456
9	Ironaton	Ironaton	Brown Ore	111,416
10	Raimund, No. 2	Bessemer	Hematite	86,965
11	Houston	Rickey	Brown Ore	79,307
12	Docray	Docray	Brown Ore	71,996
13	Raimund, No. 3	Bessemer	Hematite	68,295
14	Tannehill	Goethite	Brown Ore	65,997
15	Valley View, No. 2	Birmingham	Hematite	51,446

Beneficiated Iron Ore.

Statistics of beneficiated iron ore were gathered by the Survey for the first time during the canvass for the year 1914 and, although complete returns were not at first received from every producer who subjects his ore to any form of beneficiation, the responses to the special inquiries have been, on the whole, satisfactory and interesting, and they showed continued improvement in 1915 and 1916.

The following processes were reported as employed to improve the quality of the ore at various mines: Crushing and screening, drying by direct heat and by steam, hand picking on tables and on belts, washing by means of hydraulic jets and logs, jigging, electromagnetic cobbing, other concentration and separation, calcining, nodulizing, and desulphurization by sintering. Some of the operations combined two or more of these processes. Iron ores were reported as beneficiated at 83 mines in 14 States in 1916 and at 66 mines in 14 States in 1915, and in addition at the brown-ore mines of the Spanish-American Iron Co. in Cuba.

In Alabama the ore treated was red hematite and brown ore, and the usual processes to which it was subjected were log washing, screening, and picking belt. A total of 996,344 gross tons of beneficiated brown ore, valued at $1,969,706, was marketed from 12 mines in Alabama in 1916, compared with 744,193 tons, valued at $1,278,344, from 9 mines in 1915. Of this, 117,456 tons were hematite run over a picking belt. (E. F. B.)

PIG IRON.

Production, Shipments, and Value of Pig Iron, By States.

THE bureau of statistics of the American Iron & Steel Institute reports the production in 1916 of all kinds of pig iron, including such ferroalloys as spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus, produced in blast furnaces as well as some that were electrically produced as 39,434,797 gross tons, compared with 29,916,213 tons produced in 1915, an increase of 9,518,584 tons, or 32 per cent.

The following table gives the total production of pig iron in 1915 and 1916, by States, according to their rank each year:

*Pig iron, including some ferroalloys, manufactured in the United States in 1915 and 1916, in gross tons.**

STATE	1915	1916
Pennsylvania	12,790,668	16,506,284
Ohio	6,912,962	8,602,895
Illinois	2,447,220	3,922,512
New York, New Jersey	2,104,780	2,352,535
Alabama	2,049,453	2,762,885
Indiana, Michigan, Wisconsin	1,986,778	2,221,708
Minnesota	372,966	811,325
West Virginia, Kentucky, Missouri, Iowa†, Colorado, Washington, California	291,040	554,590
	271,921	437,633
Maryland	251,548	501,452
Virginia	251,346	399,885
Tennessee	177,729	355,374
Connecticut, Massachusestts	7,802	5,719
	29,916,213	39,434,797

*Bureau of Statistics of the American Iron & Steel Institute.
†Ferrosilicon produced in electric furnace for first time in 1916.

Pig iron shipped from blast furnaces in the United States in 1915 and 1916.

STATE	1915		1916		Increase in 1916		Percentage of increase in 1916.	
	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity (gross tons)	Value	Quantity	Value
Alabama	2,320,255	$23,757,124	2,672,498	$38,994,660	352,243	$15,237,536	15	64
Illinois	2,455,894	34,207,901	3,857,391	67,764,309	1,401,497	33,556,408	57	98
Kentucky	105,700	1,420,275	144,444	2,595,600	38,744	1,175,325	37	83
Michigan	486,106	6,624,559	505,646	8,851,361	19,540	2,226,802	4	34
New York	2,010,076	28,178,466	2,289,608	40,537,240	279,532	12,358,774	14	44
Ohio	6,995,000	90,549,626	8,689,030	136,855,228	1,694,030	46,305,602	24	51
Pennsylvania	12,779,974	174,926,891	16,351,131	293,437,782	3,571,157	118,510,891	28	68
Tennessee	208,298	2,519,337	329,342	4,981,538	121,044	2,462,201	58	98
Virginia	265,616	3,408,784	444,491	7,140,002	178,875	3,731,218	67	109
Wisconsin	302,913	3,997,940	423,973	7,534,327	121,060	3,536,387	40	88
Other States‡	2,454,654	31,818,701	3,418,770	54,786,071	964,116	22,967,370	39	72
	30,384,486	401,409,604	39,126,324	663,478,118	8,741,838	262,068,514	29	65

‡1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

Average Prices.

The average price per gross ton of all kinds of pig iron, by States, from 1911 to 1916, given in the following table is based on reports of the manufacturers to the Survey. These figures represent the prices at the blast furnaces and do not include the prices of ferroalloys.

The average prices for 1915 and 1916 appear low for such active years in the iron industry. Prices, however, did not revive as rapidly as production, and in the early months of the year orders were taken at low prices for delivery late in the year by many producers who did not clearly foresee the future possibilities. At the close of 1915 market prices of pig iron were 35 to 40 per cent above the average for that year and at

the close of 1916 they were between 45 and 68 per cent higher than at the beginning of the year, but this increase was confined almost entirely to the last two or three months of the year, so that the average increase in price was only 28 per cent.

Average price per gross ton of pig iron in the United States, 1911 to 1916.

STATE	1911	1912	1913	1914	1915	1916
Alabama	$10.75	$10.75	$12.08	$10.52	$10.24	$14.59
Illinois	15.30	15.26	15.83	13.59	13.93	17.57
Kentucky	15.01	15.74	16.09	12.24	13.44	17.97
Michigan	15.34	14.30	14.69	13.78	13.63	17.51
New York	15.56	14.22	15.35	14.26	14.02	17.70
Ohio	13.68	13.07	15.02	13.46	12.96	15.75
Pennsylvania	14.23	14.60	15.36	13.78	13.69	17.95
Tennessee	11.56	12.29	13.22	12.05	12.09	15.13
Virginia	12.62	13.27	13.96	12.53	12.83	16.06
Wisconsin	15.51	14.33	15.13	13.35	13.20	17.77
Other States*	14.94	14.07	15.50	13.55	12.96	16.03
Average for United States	14.07	13.93	15.08	13.42	13.21	16.96

1911: California, Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1912 and 1913: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey and West Virginia; 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1916: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

Blast Furnaces.

The number of furnaces in blast on June 30 and December 31 and the total number of stacks recorded for the years 1915 and 1916, not including any electric reduction furnaces, as published by the bureau of statistics of the American Iron and Steel Institute, are as follows:

Blast furnaces in the United States, 1915 and 1916.

STATE	Furnaces in blast June 30, 1915.	Dec. 31, 1915			Furnaces in blast June 30, 1916	Dec. 31, 1916		
		In.	Out.	Total.		In.	Out.	Total.
Pennsylvania	96	125	31	156	132	127	30	157
Ohio	50	62	12	74	67	65	12	77
Illinois	12	21	5	26	23	24	0	24
Alabama	20	27	20	47	31	29	18	47
New York	16	18	9	27	20	18	9	27
Virginia	5	7	15	22	9	9	13	22
Tennessee	5	6	12	18	12	11	7	18
Colorado	2	2	4	6	4	3	3	6
Iowa					0	0	0	0
Missouri	1	1	1	2	1	2	0	2
Oregon	0	0	1	1	0	0	1	1
Washington								
California	0	0	0	0	0	0	0	0
Maryland	2	3	2	5	4	4	1	5
New Jersey	1	1	4	5	1	1	4	5
Wisconsin	4	7	1	8	6	5	3	8
Minnesota	1	2	0	2	3	3	0	3
Indiana	10	10	0	10	10	10	0	10
Michigan	8	11	3	14	12	12	2	14
West Virginia	1	3	1	4	4	4	0	4
Kentucky	1	3	3	6	4	4	2	6
Georgia	0	0	4	4	0	0	4	4
Texas	0	0	2	2	0	0	2	2
Mississippi	0	0	1	1	0	0	1	1
Connecticut	1	1	2	3	0	1	2	3
Massachusetts	0	0	2	2	1	1	1	2
	236	310	135	445	344	333	115	448

Of the ferro-alloys used in the manufacture of steel only the ferro-manganese and spiegeleisen are manufactured in Alabama at two localities. In 1916 ferro-manganese was valued at $134.42 a long ton, and spiegeleisen at $33.68 a ton as against $64.14 and $20.98 a ton respectively for 1915. This great increase in value stimulated the search for deposits of manganese in the State, but production in very limited quantity by one company only has been reported for 1916 in the State.

Steel.

The figures for the production of steel in Alabama in 1916 are not available for publication.

LIME.

DURING the year 1916 there was an increase in the production of lime in Alabama, as compared with the production of the preceding year. The total product of 9 plants in 1916 was 67,524 short tons, an increase from 1915 of 7,192 tons, or 11.92 per cent.

The value of the product was $312,531, an increase of $62,304 or 24.89 per cent.

The most important use of the lime produced was for building purposes, 11.32 per cent of the product is definitely so credited in the returns while the greater part of the lime sold to dealers and most of the hydrated lime go to building purposes. Other chief uses of lime are in chemical works, paper mills, tanneries, agriculture, manufactories of sand-lime brick, slag cement, etc.

Shelby County, as heretofore, was the largest producer in 1916, being credited with 52,809 tons or 78.21 per cent of the total. The other producing counties in the order of their importance are Blount and Jackson.

The following tables give some additional data on the lime production in Alabama in 1915 and 1916.

For a full account of the lime industry in the United States, those interested are referred to the article on Lime, by G. F. Loughlin, in "Mineral Resources of the United States, 1916."

Lime burned and sold in Alabama in 1915 and 1916.

YEAR	Rank of state by quantity	Quantity (short tons)	Value	Rank of state by value	Average price per ton	Number of plants in operation
1915	16	60,332	$250,227	17	$4.15	14
1916	16	67,524	312,531	23	4.63	9
Increase		7,192	62,304			
Percentage		11.92	24.89			

Lime sold in Alabama in 1915 and 1916, by uses.

	Quantity (short tons)	Value	Average price per ton U. S.
1915			
Building lime	13,177	$54,976	*$4.26
Chemical works	1,369	5,769	3.36
Paper mills	†	†	3.61
Sugar factories	801	3,368	6.77
Tanneries	†	†	4.06
Agriculture	379	1,308	*3.21
Dealers, uses not specified	40,031	169,600	4.22
Other uses and undistributed	4,575	15,206	.....
Total	60,332	$250,227	.....
Hydrated lime (included in total)	6,302	28,553	.....
1916			
Building lime	7,744	$33,069	$5.21
Chemical works	703	2,571	3.70
Paper mills	†	†	4.14
Sugar factories	.....	.....	5.41
Tanneries	†	†	4.64
Agriculture	592	2,246	3.63
Dealers, uses not specified	50,007	243,582	4.95
Other uses, and undistributed	8,478	31,063	.....
Total	67,524	$312,531	.....
Percentage of increase in 1916	11.92	24.89	.....
Hydrated lime (included in total)	6,780	36,864	.....
Percentage of increase in hydrated lime in 1916	7.58	29.11	.....

*Revised. †Included in "Other uses and undistributed."

MANGANESE.

THERE has been very little production of manganese during the past few years. Only one company has reported production in 1916 from near Walnut Grove in Etowah County. A second firm has reported some progress in development. Because of the great demand for manganese in the time of

the war, thorough investigation should be made of some of the most promising localities. Among these localities worthy of further investigation are Murphree's Valley in Blount and Etowah, Shinbone Valley in Clay County, and many other localities in Etowah, St. Clair, Calhoun and Cleburne counties mentioned in the State Geological reports. In the Shinbone Valley along the eastern foot hills of the Talladega Mountain range, there is a practically continuous outcrop of manganese ore which can be followed up to the southern boundary of Cleburne County.

Many specimens of high-grade merchantable ore have been collected from these outcrops, but the prospecting has not yet shown that the quantity of such high-grade ore will justify the working on commercial scale.

MICA.

MICA mines were opened in Alabama during the early days of mica mining in the Southern States. Prospects have been tested at various subsequent times, and considerable mining has been carried on at intervals during the last twenty years.

The mines are located in Randolph, Cleburne, Clay and Tallapoosa counties, and there are prospects also in Lee, Coosa, and Chilton counties.

In 1916 there were six mines producing mica as against four in 1915. The output was 14,132 pounds of sheet mica, valued at $4,955, and a few hundred dollars worth of scrap mica.

The output of sheet mica in 1915 was 8,400 pounds valued at $5,545, showing an increase in 1916 of 5,732 pounds or 68.24 per cent, but a decrease in the value of $590.00 or over 10 per cent.

MINERAL WATERS.

By Arthur J. Ellis.

Character of Statistics.

THE statistics given in this report have been compiled from individual reports furnished by the owners or operators of springs, and include, so far as can be ascertained, only natural waters that are bottled and sold in their natural state or only slightly altered from their natural state. Natural still waters that have been artificially carbonated, natural carbonated waters that have lost part of their carbon dioxide, and waters from which iron has been removed are included; but artificial waters and natural waters that have been flavored, concentrated, fortified, diluted, or otherwise essentially modified in chemical character are excluded if available information indicates such treatment. Water given away or consumed at spring resorts, which constitutes a large part of the annual production, is excluded. Waters sold at flat or meter rates, delivered to consumers through pipes, or otherwise obviously municipal supplies or adjuncts to them are excluded. This is the nearest practicable conformity with the commonly accepted definition of natural mineral water. No distinction is made between mineral water flowing or pumped from a natural spring and that flowing or pumped from a dug, bored, driven, or drilled well. Many of the best-known mineral waters in the United States come not from natural springs but from wells.

Distinction for statistical purposes between table and medicinal waters is entirely arbitrary. Most table waters are clear, sparkling, and without distinct mineral taste or odor; many medicinal waters are highly mineralized and have distinct mineral taste and odor. Yet some table waters are more strongly mineralized than some medicinal waters, and many medicinal waters contain less mineral matter than certain city supplies. The basis here used for distinguishing medicinal from table waters is the report regarding the spring, and this distinction is based in turn on the operator's knowledge that some of his customers buy the water to use regularly on their

tables and others buy it for an aid during illness. A few strongly mineralized waters are not sold as table waters, and a few widely sold table waters are not used medicinally, but many waters are sold for both uses, though the reported sales of several medicinal waters have distinctly decreased in the last few years.

Mineral Water Trade in Alabama, 1916.

Returns from Alabama indicate that the mineral-water trade in 1916 was about 20 per cent more than that in 1915. The sales amounted to 103,944 gallons, and the value of the output was $12,174, the average price per gallon increasing from 10 cents to 12 cents. There was a considerable decrease in the value of the output of medicinal waters, but the large increase in the sales of table waters netted a gain of $3,262 in the total sales. Sixteen springs reported sales. One spring which was active in 1915 reported no sales for 1916. Gordon Mineral Springs is newly added to the list. Seven mineral-water bathing establishments and 5 resorts, accommodating about 800 guests, were maintained. The quantity of mineral water used in the manufacture of soft drinks increased from 2,300 gallons to 13,500 gallons.

The following 16 springs reported sales:

Bailey Springs, Florence, Lauderdale County.
Bladon Springs, Bladon Springs Choctaw County.
Blount Springs, Blount Springs, Choctaw County.
Bromberg Gulf Coast Lithia Spring, Bayou Labatre, Mobile County.
Cooks Springs, Cooks Springs, St. Clair County.
Dixie Spring, Dixie Spring, Walker County.
Gordon Mineral Springs, Canoe, Escambia County.
Healing Springs, Healing Springs, Washington County.
Livington Mineral Well, Livingston, Sumter County.
Luverne Mineral Spring, Luverne, Crenshaw County.
McCary Mineral Well, near Birmingham, Jefferson County.
Matchless Mineral Water Well, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
Shocco Springs, Talladega, Talladega County.
Talladega Springs, Talladega Springs, Talladega County.
White Sulphur Wells, near Jackson, Clarke County.

The following tables add some details to the general statements above given:

Mineral waters sold in Alabama in 1915 and 1916.

YEAR	Commercial Springs	Quantity Sold (gallons)	Average price per gallon (cents)	Value of medicinal waters	Value of table waters	Total value
1915	14	86,499	10	$8,213	$699	$8,912
1916	16	103,944	12	5,979	6,195	12,174

Comparative production of mineral waters in Alabama in 1915 and 1916.

YEAR	Commercial Springs	Quantity sold (gallons)	Value of product
1915	14	86,499	$8,912
1916	16	103,944	12,174
Increase	2	17,445	3,262
Percentage of increase		20	37

A comparison of American and European Mineral waters, by Alfred A. Chambers, is given in "Mineral Resources of the United States, Part II, pages 500-508." A discussion of the waters of Alabama, may be found in a report of the Geological Survey of Alabama, "Underground Waters of Alabama," by Eugene A. Smith, State Geologist, 1907.

NATURAL GAS.

By JOHN D. NORTHROP.

IN 1916 natural gas in sufficient volume to supply the needs of 250 domestic consumers in Fayette, was obtained from four wells, one of which was completed during the year in the Fayette Gas Field, Fayette County, and enough for the needs of 85 domestic consumers in the town of Jasper, was obtained from two wells in Walker County.

Wild cat tests drilled in 1916 in quest of petroleum near Mobile, Mobile County, in southern Alabama, resulted in the discovery of numerous pockets of natural gas, but no commercial production of gas.

Nine wells in Madison County and one in Winston County in northern Alabama were reported closed in 1916.

Some details concerning the oil and gas situation in Alabama may be found in Bulletin 10 of the Geological Survey, Report on the Fayette Gas Field by M. J. Munn, and in Circular No. 3 Concerning Oil and Gas in Alabama, by Eugene A. Smith.

PETROLEUM.

By JOHN D. NORTHROP.

NOTHING of consequence resulted from the quest for petroleum in Alabama in 1916. Late in December the discovery of oil in small quantities near Cordova, Walker County, furnished the basis for considerable local excitement, which, however, failed to result in the opening of a new field. So-called blow-outs near Mobile provided an incentive for drilling in that locality, and at the end of 1916 tests were under way west of that city.

SAND AND GRAVEL.

THE total production of sand and gravel in the State in 1916 was 726,650 short tons, valued at $184,216, as compared with 924,701 tons, valued at $242,336 in 1915, a decrease in the quantity of 198,051 tons, or 21.42 per cent, and a decrease in the value of $58,120, or 23.99 per cent.

There was an increase in the quantity of sand of 250,532 short tons, or 66.44 per cent, and in the value of $22,288, or 17.73 per cent. There was a great falling off in the quantity

and value of the gravel, viz., a decrease of 448,583 tons, or 81.91 per cent in quantity, and of $80,408, or 68.91 per cent in value.

Railroad ballast, building and molding sands make 91.61 per cent of the sand production; railroad ballast 41.58, building 35.11 and molding sand 20.92 per cent, while the balance of 2.39 per cent represents the production of grinding and polishing, paving and other unclassified sands.

The following tables give a comparison of the production of sand and gravel in 1915 and 1916, and the production, value and kinds of sands in these two years.

Production in short tons of sand and gravel in Alabama in 1915 and 1916.

	SAND		GRAVEL		Total*		Percentage of U. S. total
	Quantity	Value	Quantity	Value	Quantity	Value	
1915	377,045	$125,664	547,656	$116,672	924,701	$242,336	1.05
1916	627,577	147,952	99,073	36,264	726,650	184,216	0.62
Increase or decrease	+250,532	+22,288	—448,583	—80,408	—198,051	—58,120	0.62
Percentage	+ 66.44	+ 17.73	— 81.91	— 68.91	— 21.42	— 23.99	.....

*Chert has been added to these totals.

Quantity (short tons), value and kind of sand produced in Alabama in 1915 and 1916.

	Moulding Sand		Building Sand		Paving Sand		Engine Sand		Grinding and Polishing Sand		Railroad Ballast Sand and Gravel		Other Sands		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1915	169,663	$59,862	157,581	$51,788	*	*	6,942	$1,779	*	*	*	*	7,294	$2,180	377,045	$125,664
1916	131,312	41,470	220,336	66,989	*	*	6,199	1,741	*	*	259,957	$32,413	*	*	627,577	147,952
Increase+ or Decrease—	—38,351	—18,392	*62,755	*15,201	.....	.....	— 743	— 38	.....	.....	.....	.....	.....	.....	+250,532	+22,288
Percentage	— 22.60	— 30.72	+ 39.82	+ 29.35	.....	.....	—10.70	—2.14	.....	.....	.....	.....	.....	.....	+ 66.44	+ 17.74

*Concealed because of less than three producers.

STONE.

EUGENE A. SMITH.

ON ACCOUNT of the variety of uses to which stone is put, there is no regular unit of measurement, and the figures in this report represent the values of the different varieties.

PRODUCTION.

Alabama produces only three kinds of stone, viz., limestone, marble and sandstone.

The total value of the stone produced in Alabama shows an increase in 1916 of 67.17 per cent. The greater part of this increase was in the limestone, (rough and dressed building stone, and furnace flux). There was a notable decrease in the sandstone, while the production of marble was practically the same as in 1915. Exact figures for marble, however, cannot be given as there were in 1915 as well as in 1916 only two producers.

The following table gives some additional details of the total stone production:

Total value of stone (limestone, sandstone and marble) produced in Alabama in 1915 and 1916. Percentage of total U. S. value, rank of State and number of plants.

Year	Total Value	Percentage of total U. S. value	Number of Plants	Rank of State
1915	$719,452	.96	25	28
1916	1,202,256	1.52	25	20
Increase in 1916	482,804			
Percentage	67.17			

LIMESTONE.

The most important use of limestone produced in Alabama in 1916 as in 1915, was for furnace flux, while building stone, both rough and dressed, follows next in importance. For the other uses given in the table the value of the limestone shows

a decrease, notably in the case of the stone used in road-making.

The limestone burned into lime or used in the manufacture of Portland cement is not taken into account here, but is included in the value of each of the finished products in whose manufacture it was used.

As thus limited the total value of the limestone produced in 1916, was $917,559, as compared with $426,266 in 1915, an increase of $491,293 or 115.26 per cent.

The value of the limestone produced in Alabama in 1915 and 1916 classified according to the uses of the stone is given in the following table:

Value of limestone (not including marble) produced in Alabama in 1915 and 1916, according to uses.

USES	1915	1916	Increase or Decrease	Percentage
Rough building	$6,912	$13,067	+ $6,155	+ 89.19
Dressed building	15,487	29,597	+ 14,110	+ 91.11
Riprap	18,379	17,969	— 410	— 2.23
Crushed Stone:				
Road making	42,116	1,198	— 40,918	— 97.15
Railroad ballast	554	180	— 374	— 67.51
Concrete	45,443	41,321	— 4,122	— 9.03
Flux	289,167	807,344	+ 518,177	+ 179.19
Agricultural	7,386	4,656	— 2,730	— 36.96
Other	822	2,227	.....	.....
Total	$426,266	$917,559	+ 491,293	+ 115.26

Limestone For Building Purposes.

The preparation of cut stone for building purposes in Alabama, while on the increase, is not yet what it should be. Practically all of this material comes from the quarries in the subcarboniferous limestone of the Tennessee Valley, the most important quarries being at Rockwood in Franklin County, operated by Foster and Creighton Co., of Nashville. This stone is quite similar in appearance, composition, and other qualities to the Indiana stone, and so far as experience in the use of the stone from the two localities in the buildings of the

University of Alabama goes, the Alabama stone holds its own under influence of the weather better than does the Indiana stone. Stone steps, door sills, and window sills, buttress caps, etc., of the Alabama stone put in place in 1885 show practically no deterioration in color and wear under foot, and in crumbling and roughening under the influence of the weather, which cannot be said of some portions of the Indiana stone used in buildings erected in 1909-10. The Rockwood quarries have most modern and approved methods of machinery for sawing the stone and handling it in transit to the mills and elsewhere. The stone is of massive formation, of great thickness and extent. Blocks weighing as much as 25 tons, without crack or flaw, are not infrequently quarried, the size of the blocks being practically limited only by the capacity of the hoisting machinery.

The Oolitic variety is most extensively used for building and monumental work. It is of light gray color, uniform grain, and homogeneous texture. It possesses a quality of cheapness, it can be cut to any design required, and is at the same time strong and durable.

With the installing of adequate machinery at the quarry for doing the finished work, there should never be any longer any reason for going outside of the State for this quality of stone. Already the material has been very extensively used in public buildings in Mississippi, Tennessee, as well as in Alabama. The only reason why it was not used in the recently erected buildings at the University of Alabama was that at the time these building contracts were let, the quarries furnished only the rough sawn stone and there was not in Alabama any establishment adequately equipped for the dressing of the stone in the quantity needed.

The above statements are confirmed by a report on the comparative tests made on the Rockwood stone, and those from Bedford, Ind., and Bowling Green, Ky., by Prof. Robert H. McNeilly, in the Engineering Laboratory of Vanderbilt University.

From this report I give the following extracts:

"General Characteristics.—The Rockwood limestone is an almost pure oolitic limestone with frequent small crystals of calcite distributed throughout its mass. It resembles closely

the Bedford stone in appearance, except that it has a slightly more open texture. The Bowling Green stone is finer in grain, softer and more easily pulverized than either the Bedford or Rockwood stones, and contains an appreciable amount of petroleum, which lends somewhat to the ease with which it is worked. In all three stones the texture is exceptionally uniform, as it is almost impossible to detect the bedding planes by eye; however in this respect the Bowling Green stone is most marked, and it is frequently necessary to test by hammer to detect which is the bed plane. Rockwood stone is lighter in color than either the Bedford or Bowling Green stones.

"CHEMICAL ANALYSIS.—The following is an analysis of the Rockwood stone made at my request by Dr. Paul C. Bowers, Chief Chemist of the Tennessee Geological Department:

	Rockwood Stone.
Moisture and loss on heating to 175° C.	0.07
Insoluble siliceous residue (SiO_2, etc.)	0.49
Oxide of Iron and Alumina (Fe_2O_3 & Al_2O_3	0.30
Carbonate of Lime ($CaCO_3$)	98.23
Carbonate of Magnesia ($MgCO_3$)	0.97
Total	100.06

"PHYSICAL TESTS.—Comparative physical tests of the three samples of stone were made as follows:

Loss in weight on drying,
Cross bending tests,
Compression tests,
Absorption tests,
Per cent of water absorbed,
Specific gravity in bulk, and of pulverized stone,
Density,
Abrasion tests.

The results of these physical tests are summarized in the CONCLUSIONS below quoted.

"CONCLUSIONS.—The above tests were made as nearly as possible, under identical conditions, and barring the accidental characteristics of the samples, which were selected at random, these results are believed to represent truly the comparative characteristics of each of the stones under consideration.

"The Rockwood stone shows itself to be a superior building stone to others in every respect except density—but even here, since its absorption of water is the lowest of the three, it

should prove more durable, while the smaller weight per cubic foot can be placed more cheaply on account of freight charges.

"As compared with the Bowling Green stone, the Rockwood shows a decidedly higher strength, and characteristics which indicate a greater durability. The Bowling Green stone, however, is undoubtedly more easily worked than either of the other two stones, due to its being softer and also to the presence of oil. This oil has the bad effect of staining the stone itself and the contiguous masonry for several years after it is placed, while the very ease with which the stone can be worked makes the Bowling Green very inferior where used for door sills and steps. This is shown well by the Abrasion Test which shows the Rockwood stone in its best light, as a very superior material for step, door sills, and other places subject to wear.

"From my examination of these three stones, I believe no builder would make a mistake in using any one of the three, for they are all unquestionably very superior building stones. While each stone may have advantages over the other for some specially desired characteristics, as a building stone for general purposes, each is highly satisfactory.

Respectfully submitted,
ROBERT H. MCNEILLEY,
Assistant Professor of Civil
Engineering, Vanderbilt University."

MARBLE.

The marble of Alabama is of two kinds, crystalline, or true marble, and non-crystalline.

The crystalline or statuary marble occurs mainly in a narrow valley along the western border of the metmorphic area, extending from Marble Valley in Coosa County, through Talladega into Calhoun. The length of the marble belt through Coosa and Talladega counties is about 50 miles. The width of the valley carrying the marble as a rule is from one quarter to one-half mile, widening in places to a mile and a quarter, for example in the neighborhood of Sylacauga.

The quarries longest known are Gantt's and Herd's near Sylacauga, Nix's near Sycamore, Bowie's near Rendalia, and Taylor's and McKenzie's near Taylor's Mill, east of Talladega. From all of these marble was quarried before the civil war.

During 1916 two companies reported production of marble in Alabama, viz., the Alabama Marble Company at Gantt's Quarry and the Moretti-Harrah Company, whose quarry adjoins that of the Alabama Marble Company at Gantt's. The other quarries mentioned are in Talladega County, near Sylacauga.

The plant of the Alabama Marble Company at Gantt's Quarry which was completely destroyed by fire in December, 1910, has been rebuilt and equipped with all the machinery needed for the working up of any kind of finished product.

I think it is fairly safe to say that on the whole the marble from this quarry and immediate vicinity is of the highest grade of commercial white marble now on the market and obtainable in large quantity. There are small quantities of marble produced both in Italy and Vermont that are somewhat freer from coloring matter than the best grades that can be produced in Alabama in any quantity. But on the other hand, the poorest grades in Alabama greatly surpass the poorest grades produced elsewhere, so that the average of the Alabama deposit is probably somewhat higher than that of any other so far developed, not excluding even the marble from the Carara district in Italy. The marble from this State (Gantt's Quarry) has now a well established reputation and has been used in more than 200 important buildings throughout the United States.

It can be seen in the galleries of the National Museum in Washington.

The Moretti-Harrah Company furnishes the marble in blocks for monumental and rough interior purposes.

A beautiful quality of variegated limestone or marble—red, pink and white—belonging probably to the Cambrian formation, occurs in Shelby County, a mile or two south of Shelby Springs station on the L. & N. railroad, and extending thence southwest for a mile or two. Nothing but prospecting work has been done on this marble. The Trenton limestone in the Appalachian valleys, particularly Jones Valley below Bessemer, contains marble similar to that quarried in the vicinity of Knoxville, Tenn. Also at Pratt's Ferry on the Cahaba River in Bibb County a quarry was for many years worked in this formation and turned out a very beautiful quality of marble

varying in color from gray through pink, red and brown shades.

A black marble which is exceedingly promising, has been reported and some development work done near Anniston, and at Piedmont, Calhoun County, and some very handsome specimens of cave onyx have been obtained from near Kymulga in Talladega County.

In the Coastal Plain the St. Stephens limestone of the Tertiary holds ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white, through shades of yellowish into red, and it would make a handsome decorative marble, especially for inside work.

Other limestone formations, such as the Subcarboniferous and the Knox Dolomite, could in places be drawn upon for marble.

Sandstone.

The returns to the U. S. Geological Survey office show a decrease in the total value of the sandstone produced in 1916, of $9,437 or 31.01 per cent, as compared with the 1915 production.

By far the greater part of the sandstone produced in 1916 was ganister.

The following table will show the limestone and sandstone production of Alabama from 1912 to 1916 inclusive:

Value of limestone and sandstone production in Alabama, 1912-1916.

KIND	1912	1913	1914	1915	1916
Limestone	$531,085	$812,664	$787,214	$426,266	$917,559
Sandstone	27,596	151,111	161,773	30,432	20,995

SUMMARY.

BECAUSE of the difference in units of measurement employed in the various branches of the mineral industry, a summation of the production of the year can include only the values of the products. It is also to be noted that a simple summation of all the values of the minerals or mineral products listed in this pamphlet would give a value much in excess of the true value, since in many cases, as for instance coal and coke, and iron ore and pig iron and steel, the second product is directly a product of the first, and the value of the first is included in that of the second. To give the values of both as a part of the total would be to repeat, in a measure, at least a partial value of the first or raw product and would give an erroneous result.

As the Survey has not, however, the figures upon which to base an estimate of the percentage of each product which was used in the manufacture of some other product, the summation of the mineral production of the State as here given will be a simple summation of the values reached by the individual branches of the industry.

According to this rather unsatisfactory manner of summation, which does not include the value of the steel produced, the value of the 1916 raw materials and immediately derived products was $94,987,229, as compared with $61,791,958 in 1915; an increase of $33,195,271, or 53.72 per cent.

This production may be classified as follows:

Raw products	$40,973,430
Pig iron	38,994,660
Coke	15,019,139
Total	$94,987,229

The more important minerals and products after coal, pig iron and coke, are iron ores, clay products, stone, cement, sand and gravel, and lime given in the order of their relative importance.

Below is a tabular presentation of the value of the mineral products of Alabama, as estimated above for the years 1911, 1912, 1913, 1914, 1915, and 1916:

Year	Value
1911	$52,772,951
1912	60,141,793
1913	67,530,089
1914	56,769,559
1915	61,791,958
1916	94,987,229

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